AGRICULTURAL ENGINEERING

DECEMBER • 1951

The Return-Stack Orchard Heater Achieves Smokeless Combustion *A. S. Leonard*

The Oil-Burning Crop Drier for Hay, Grain, Corn and Other Crops *Vernon H. Baker*

Calculation and Design of the Cutterhead and Silo Blower *G. Segler*

The Irrigation Requirements of Agricultural Crops *Harry F. Blaney*

A Mathematical Analysis of the Poultry Ventilation Problem *Myron G. Cropsey*

ASAE Winter Meeting · Chicago, Ill., December 17-19

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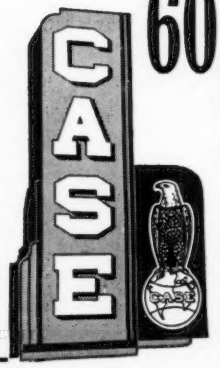

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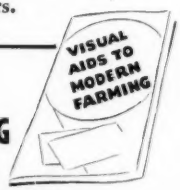

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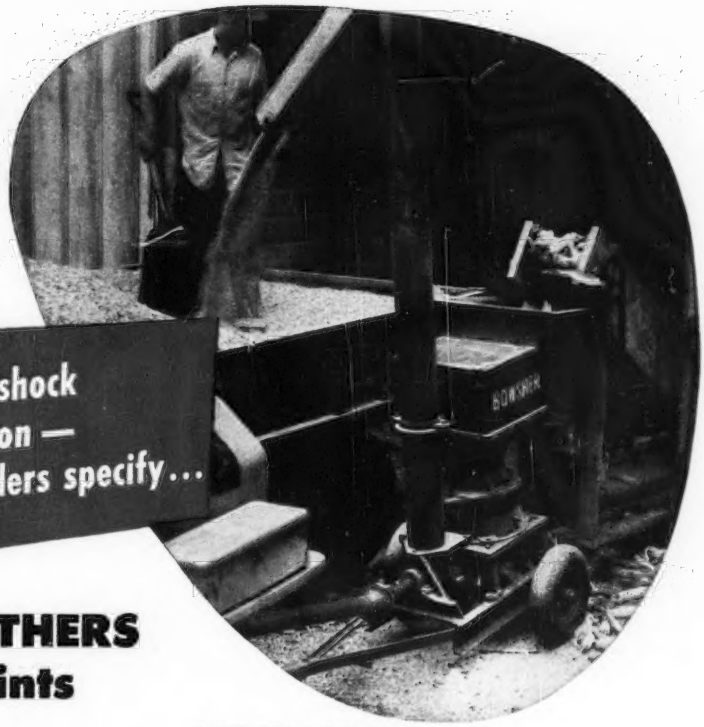

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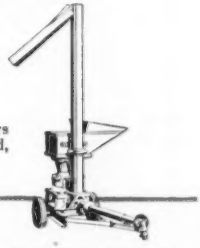

On this burr mill, Blood Brothers integral safety shields are used, also quick-detachable fittings.

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AGRICULTURAL ENGINEERING

Established 1920

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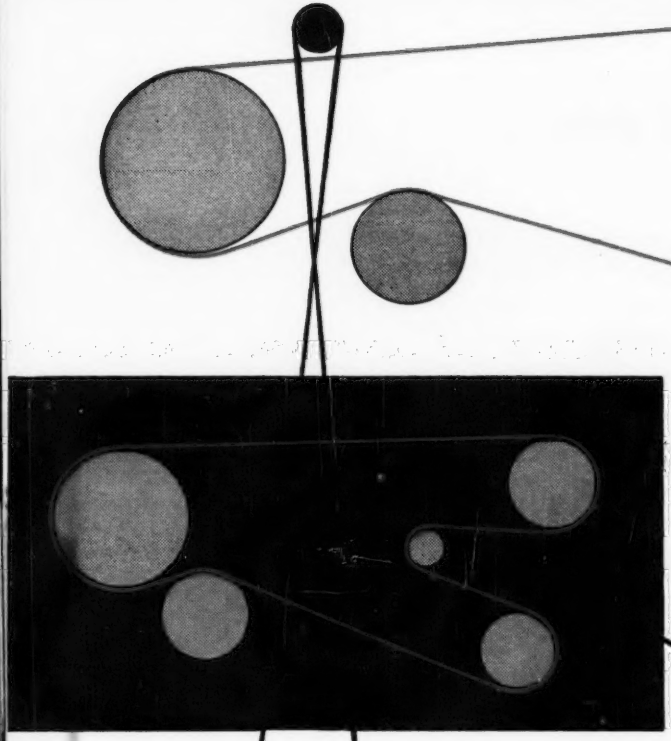

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On thousands of farms, beef and dairy cattle, sheep and hogs are kept dry and comfortable through winter months by all-steel, wind-resistant Quonsets.

Quonsets offer farm operators more, though, than safety and durability because they are multi-purpose buildings. They're designed for machinery and grain storage, as well as animal housing—engineered to step up farm production, cut time and drudgery to a minimum. The Quonset is a real working tool—more important in these days of increased livestock production and less manpower than ever before.

SHEEP HOUSING PROBLEM SOLVED. In this Quonset 24, Charles Fishel of Belle Fourche, S. D., sheltered 150 ewes during the icy winter months and the lambing season.

QUONSET 24

QUONSET 32

QUONSET 40

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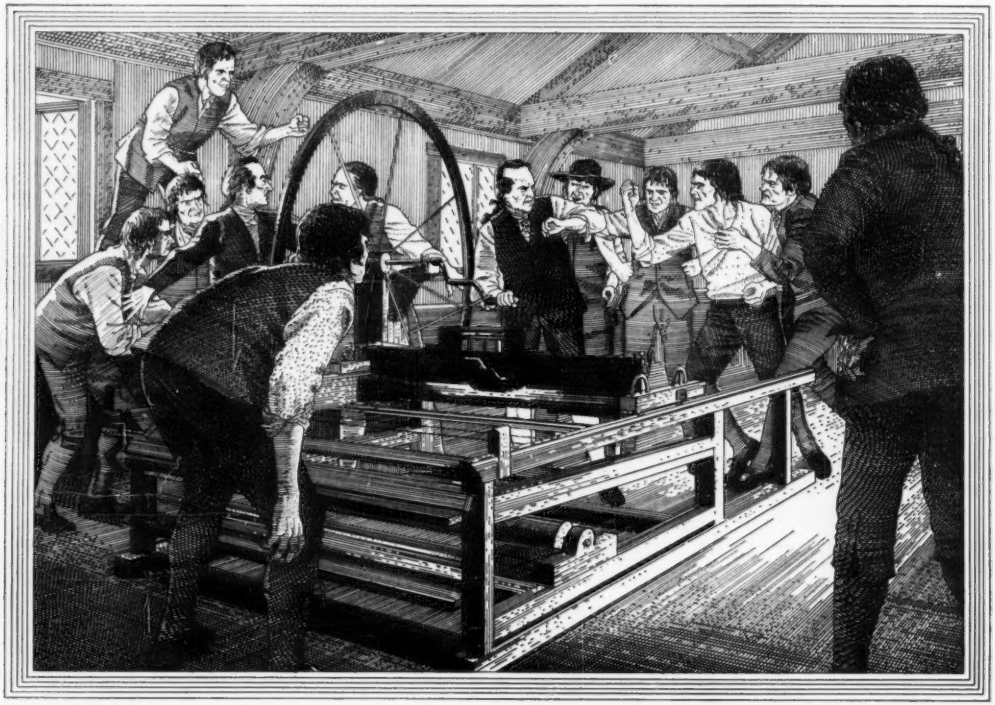


This craftsman's genius started a revolution!

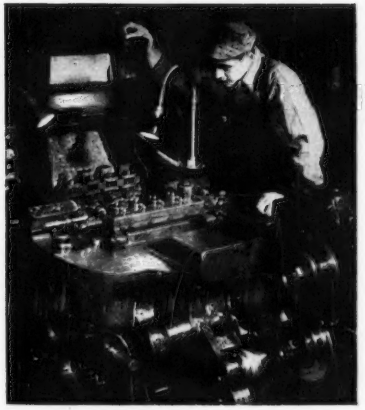
Poor British weaver James Hargreave didn't know what he started in 1757.

His spinning "jenny" spun not one, but 120 different cotton threads at a time . . . aroused his fellows who feared the machine would displace them. Ultimately, they benefited by the mass production of better, cheaper products . . . result of the Industrial Revolution which Hargreave's invention helped launch.

A clue to this craftsman's success is the heed he paid in hand-crafting every fastener. He knew that the strength of his entire assembly rested on them.

Makers of modern textile machines are even more aware of the need for quality fasteners, vital to today's stepped-up production . . . to speed and strengthen assembly, save scarce materials by reducing rejects. Fortunately, these contemporary craftsmen have *specialists* to aid them, like the Russell, Burdsall & Ward Bolt and Nut Company worker in the photograph. He devotes a craftsman's skill to producing bolts, nuts, screws and rivets of uniform accuracy, dependability and physical properties . . . backed up by 106 years of RB&W experience in making the finest fasteners.

May we apply our specialized skill to your fastener problems? We have the facilities and the ability to handle them. Address RB&W at Port Chester.



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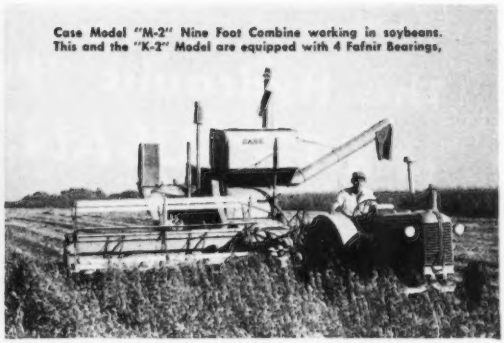
Combining oats . . . a Case Model "F-2" Five Foot Combine equipped with five 1103KLLB-3 Fafnir Ball Bearings.



Case Model "M-2" Nine Foot Combine working in soybeans. This and the "K-2" Model are equipped with 4 Fafnir Bearings.

One Way to Prevent Harvest Bottlenecks

. . . a "case" study

On the threshing cylinders and power shafts of all three Combines illustrated, Case installs Fafnir Self-aligning, Wide Inner Ring Ball Bearings with Self-Locking Collars and Mechani-Seals. This engineering strategy involves more than a reduction in friction . . . it takes advantage of a larger shaft support, bigger grease chamber, easier bearing installation, positive protection against contaminants and grease leakage.

Equipped with these bearings, vital parts of Case Combines operate longer with less attention . . . offering no threatening bottlenecks to harvesting—whatever the conditions.

The Wide Inner Ring Bearing is just one of many Fafnir types used by America's leading farm implement makers. It illustrates how Fafnir works from the bearing need to the precise bearing for the need. The Fafnir Bearing Company, New Britain, Conn.

Case Model "K-2" Twelve Foot Combine . . . uses 2 G-1108 KLLBF-2 Fafnirs on rasp-bar cylinder and 2 on fan shaft (the power shaft). When spike tooth cylinder is used, it's mounted on 2 Fafnir Flange-type LCJ 1½" units.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

Wide Inner Ring Ball Bearing with Mechani-Seals

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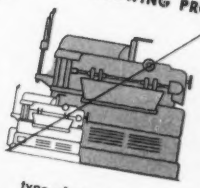
GROWING PRODUCTIVE CAPACITY



A sound, long-range expansion program which includes the periodic acquisition of new equipment has helped to cushion the shock of an unprecedented demand for Fafnir Ball Bearings. For example, within a year nearly $200,000 was invested in the very latest type of six-spindle automatics alone. Fafnir production is greater than ever before and will continue to increase as new equipment on order is delivered.

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Manufacturers have found it ideally suited to the largest variety of mobile as well as many stationary installations. It provides a compact, self-contained hydraulic system which is quickly and easily installed at low cost. Pump, relief valve, operating valves, oil tank and oil filter are all contained in the rugged, compact unit.

Vickers Power Pack is used on planters, cultivators, plows, stackers, loaders, harvesters, rakes, mowers, dump hoists, lifting tailgates, light duty scrapers, fork lift trucks, loaders, scoops, snow plows, etc. Check into its advantages for your accessory power source.

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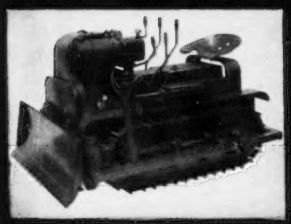
Vickers Hydraulic Power Pack provides fingertip, instant control of the twin-cylinder harvester control.



WILLCO J-7 CRAWLER TRACTOR

This powerful little general purpose tractor uses Vickers Hydraulic Power Pack for fingertip control of bulldozer blade (46" wide x 18" deep) and other attachments.

BEACON DOCK RAMP

Vickers Hydraulic Power Pack powers vertical movement (24") to level with truck or freight car floors . . . also horizontal movement (14") where outer doors must seal when board not in use.

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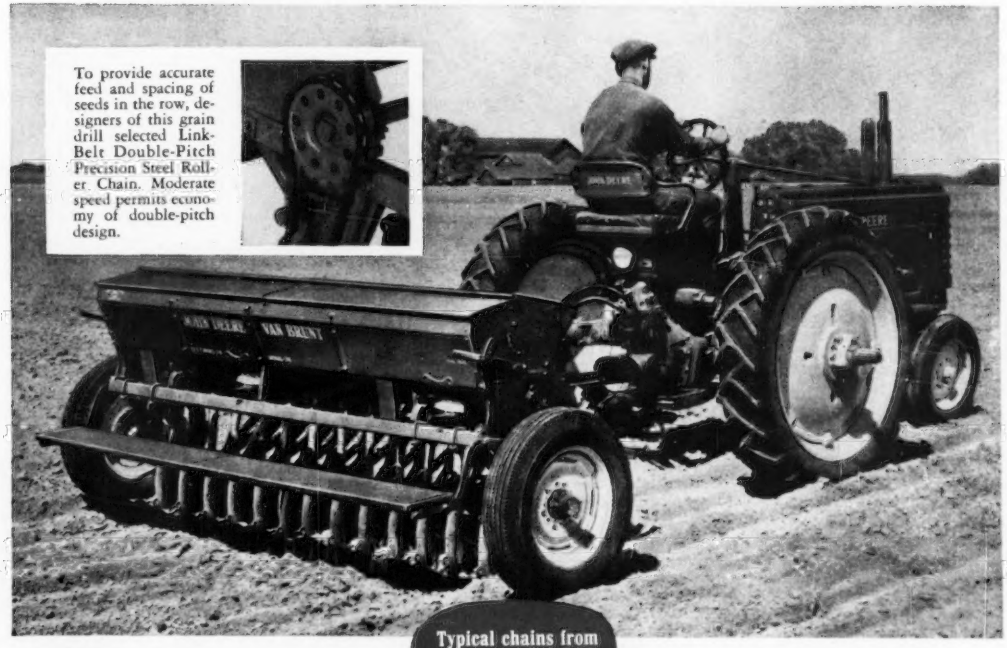

To provide accurate feed and spacing of seeds in the row, designers of this grain drill selected Link-Belt Double-Pitch Precision Steel Roller Chain. Moderate speed permits economy of double-pitch design.

Typical chains from the complete LINK-BELT line

Ewart Detachable Link-Belt, in malleable or Promal, for drives and power transmission.

Class 400 Pintle chain, in malleable or Promal, can be furnished with various attachments.

Steel Link-Belt for moderate-strength power transmission and conveying.

Link-Belt Precision Steel Roller Chain, standard pitch, for high-speed drives.

the model G replaces hand labor
IN TEST PLOTS AND NURSERIES

The Model G is the only tractor built to do power work as carefully as hand work. It is being used with remarkable success by experiment stations, nurseries, greenhouses, flower and vegetable growers to replace expensive and time-consuming hand labor.

Precision planting and cultivating implements plus unobstructed row-vision . . . speeds from ¾ mph. to 7 mph. . . . short turning radius and accurate steering . . . enable the Model G to meet the exacting requirements of specialized operations. The open-arch front end of the Model G has proved to be an advantage in mounting special equipment (above) locally designed for experimental work.

You can trust the Model G to cultivate within a fraction of an inch of valuable plants. You can seed accurately — from the smallest vegetable seeds to corn, beans and cotton. Implements can be set for any desired row spacing, and can be attached or removed from the tractor as a unit in five minutes or less. The greatest variety of specialized equipment ever designed for any one tractor is available for the Model G.

Many "hand jobs" now yield to power with the Model G. A fully illustrated catalog is available on request.

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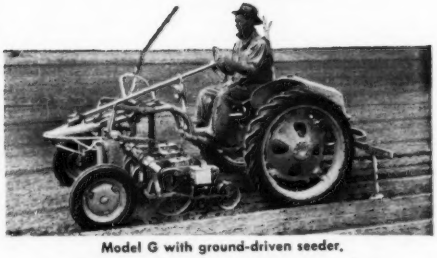
TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

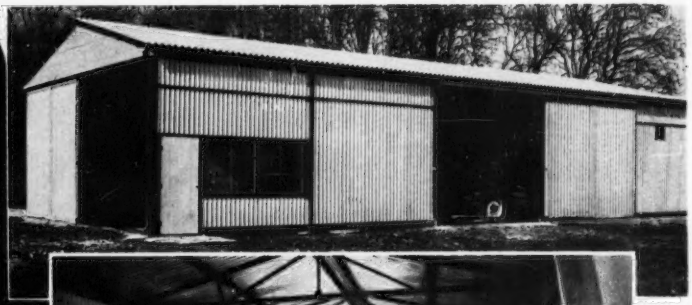


Model G with ground-driven seeder.

Model G with independent gang cultivator

"Steel is the best buy for farm buildings,"

says GLEN MERYMAN, Decatur, Illinois



● Here, word for word, is exactly what Mr. Meryman says about his steel utility buildings:

"I was so well pleased with my first all-steel utility building that I bought another one like it for my other farm.

"The layout of my building is very efficient for my needs. I installed large doors in each end of my 30′ by 68′ building plus one in the side. Thus, I can easily and quickly get at any particular piece of equipment that I need for the day's work.

"The strong, rigid U·S·S steel framework and heavy deep-box type corrugated, galvanized steel roofing and siding were pre-cut at the factory. This allowed easy erection on the farm without any wasted material.

"There are no nails to work out and leave holes to leak in my roof or side walls because the sheets are attached by means of clips and wedges on the under side. It's the fastest and best method of sheeting that I have ever seen.

"In my opinion, steel is the best buy for farm buildings from the standpoint of strength, long life, low erection and upkeep costs, insurance and safety from fire."

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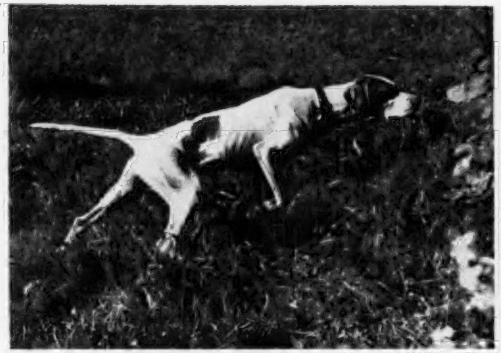

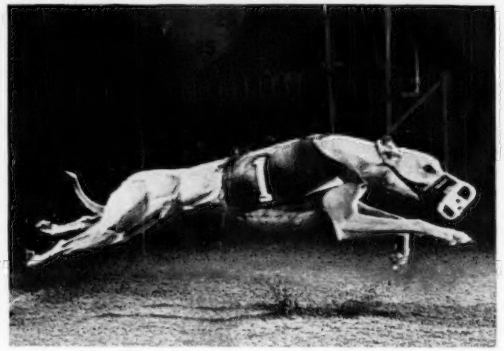

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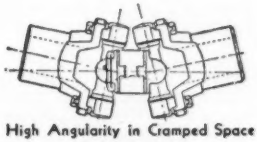

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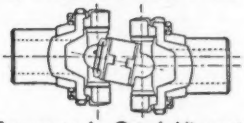

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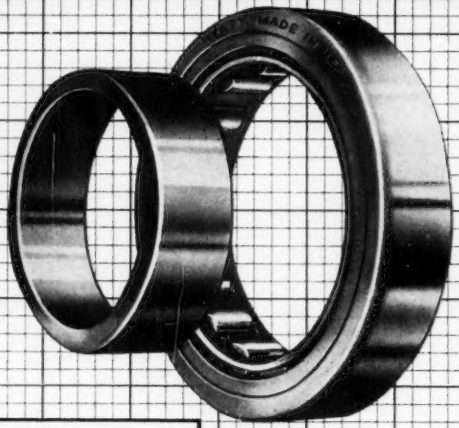

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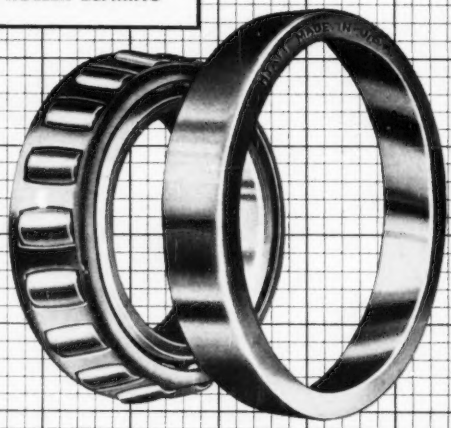

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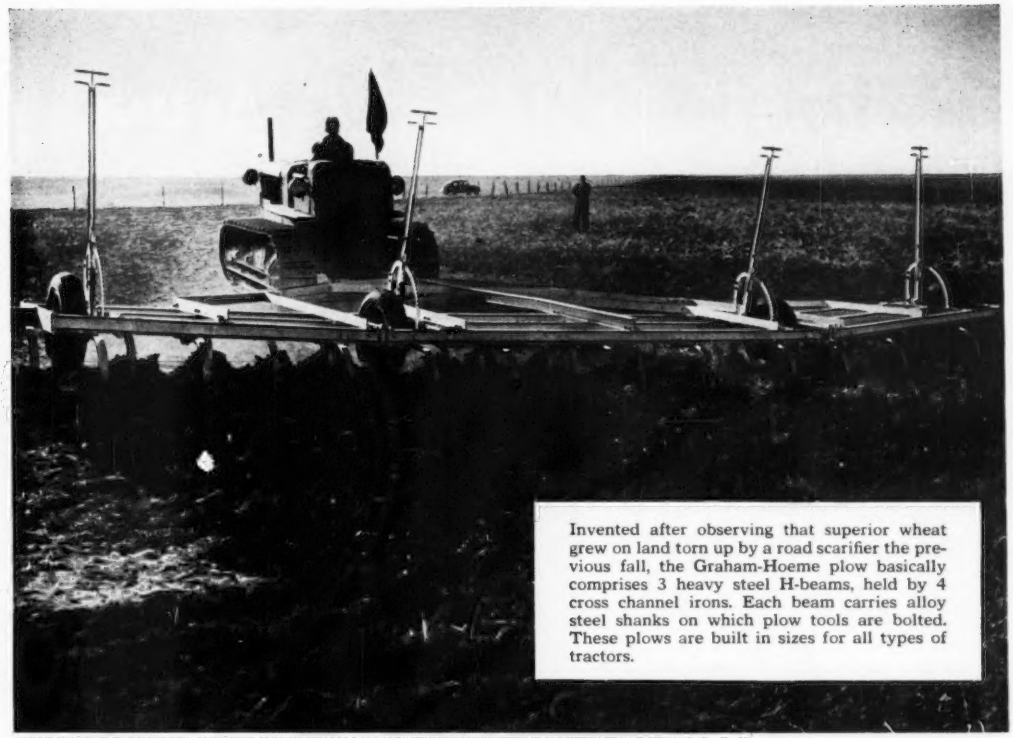

Invented after observing that superior wheat grew on land torn up by a road scarifier the previous fall, the Graham-Hoeme plow basically comprises 3 heavy steel H-beams, held by 4 cross channel irons. Each beam carries alloy steel shanks on which plow tools are bolted. These plows are built in sizes for all types of tractors.

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At the present time, the bulk of the nickel produced is being diverted to defense. Through application to the appropriate authorities, nickel is obtainable for the production of engineering alloy steels for many end uses in defense and defense supporting industries.

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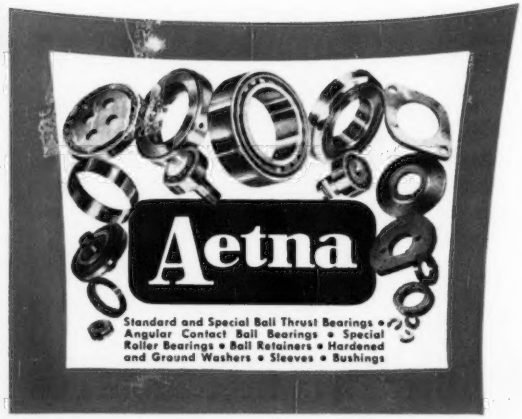
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EDITORIAL

Measure of an Agricultural Engineer

ONE way of reducing to understandable terms the job being done by agricultural engineers is to divide some agricultural quantities and results by the numbers of agricultural engineers involved. The average score per individual is surprising.

For purposes of this discussion let us consider that there are 4,000 agricultural engineers in the United States. We mean engineers actually working in some engineering capacity toward the improvement of products to meet farm service conditions, toward improved farm selection and use of engineered products, or toward other applications of engineering in or for agriculture.

If someone knows or believes the actual number to be nearer to 3,000 or 5,000, the implications will remain substantially the same.

On the 4,000 basis, there is only one agricultural engineer for every 1,250 of the 5 million farm families in this country.

There is only one agricultural engineer for each 85,000 of the 350 million crop acres in the United States.

There is only one agricultural engineer for more than 12 million dollars of investment in farm real estate and movable physical production facilities. Application of engineering principles is important to the effective use, maintenance, improvement, servicing, and replacement of the various physical items represented in this investment.

There is only one agricultural engineer for more than 5 million dollars of annual gross cash farm income. Much of this income and buying power is applied to operating expenses affected by engineering. Some of it is reinvested in engineered materials and equipment of a capital or durable goods nature.

There is only one agricultural engineer for more than 37,000 of our 150 million population depending for their very existence on the sustained efficient production of our agriculture.

At first glance it may seem improbable that more than a few agricultural engineers are exerting effective influence on such a broad scale.

The surprising fact that many are is attested by progress in farm mechanization, structures, electrification, and soil and water control, all based on sound engineering. A great deal of engineering help is being made available to agriculture with only one agricultural engineer per 33 square miles of farming enterprise.

These figures emphasize the point that agricultural engineers must achieve their effectiveness through something more than isolated individual effort. Fortunately there is no allotment of one agricultural engineer per 1,250 farm families, per 85,000 acres, or per 12 million dollars of investment. Rather the pattern is one of interconnected teams doing specialized work for much larger sections of our agriculture. It includes small and large teams of agricultural engineers. It includes teams of agricultural engineers with representatives of other branches of engineering and other applied sciences. It includes teams of agricultural engineers in research, design and development, education, promotion, and engineered farm operation; agricultural engineers in the teamwork of industry and of public service. It includes the over-all teamwork of agricultural engineers as a professional group.

It is these teams which make available the new knowledge, the improved engineered products, the more efficient methods for application in large areas of our agriculture. It is this teamwork which gives each 33 square miles of farming community much more and better engineering service than could be provided by one isolated individual engineer, however able.

Increasing demand for agricultural engineering services, together with a limited supply of new graduates, will make this team work even more important in the immediate future.

Index to Vol. 32

The title page and index to Vol. 32 of AGRICULTURAL ENGINEERING will be mailed with copies of the January, 1952, issue to ASAE members and other regular subscribers.

Financing Efficient Farming

A NEW financial approach to farming may be necessary to make the most of the improved facilities and methods being developed for farmers by agricultural engineers, agricultural scientists, and the farm supply industries.

H. N. Stapleton, head of the agricultural engineering department at the University of Massachusetts, recently pointed this out in addressing the Credit Conference of the Massachusetts Bankers Association.

The labor cost item and labor scarcity have fostered the rapidly increased farm mechanization of the past decade. At the same time, they have substantially increased the capital investment required for efficient operation.

Stapleton pointed out to the bankers that under present Massachusetts conditions an efficient one-man, 40-cow dairy will involve an investment of around $50,000. An efficient one-man, 40,000-bird, broiler-raising enterprise may involve an investment of $85,000 to $90,000.

This in part accounts for the fact that in Massachusetts 44 per cent of farm operators are over 55 years old. Only 28 per cent are under 45, and only 8 per cent are under 35. In general, the younger men who might like to farm are not able to provide the necessary capital or credit.

The old-time method of working at a disadvantage without proper equipment or on an inefficiently small scale of operation, and skimping to accumulate capital for more efficient operation, is obsolete. It cannot compete with urban industrial efficiency, or with other opportunities for labor income. It can rarely, if ever, meet present-day cash requirements for modern living in such important matters as adequate diet, sanitation, shelter, taxes, clothing, transportation, and education, not to mention the comforts, conveniences, and luxuries which farm boys and girls rightfully want to earn and enjoy before they reach retirement age.

To provide attractive opportunities in farming for more young people, without granting excess credit to unproven operators, and to make the most of modern possibilities for efficient low-cost farm production, Stapleton suggests further development of leasing arrangements.

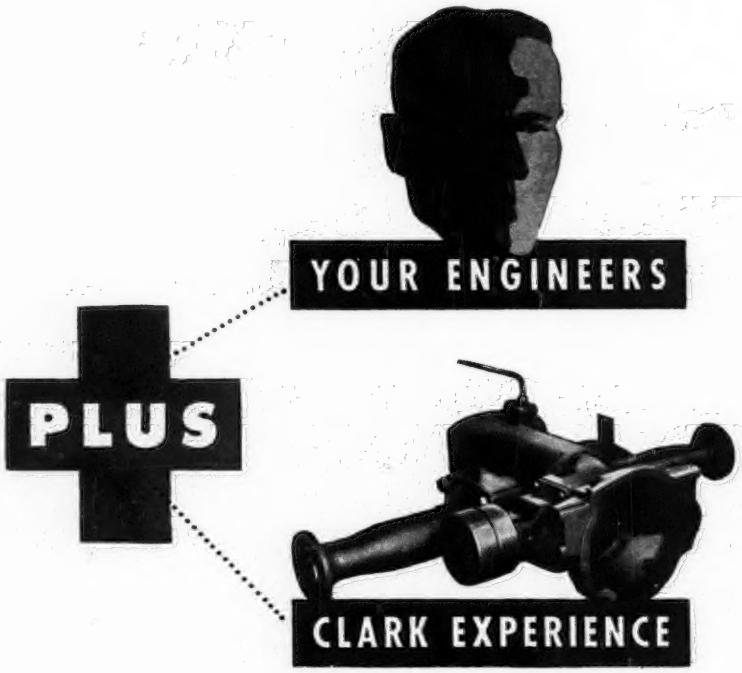
The leasing of land and buildings in many enterprises is established practice, and is not entirely new to agriculture. Leasing of other production facilities such as mobile mechanical equipment is newer, but proven feasible under provisions which adequately protect the interests of all parties to the lease.

As Stapleton has further pointed out, lease provisions which would give the young operator a tangible picture of the capital or rental cost of separate major items of his production facilities would help him to become a profitable operator. Such provisions would encourage him to give those items proper care and maintenance, and to evaluate their performance.

This line of thought suggests a major opportunity for cooperation between agricultural engineers and organizations or individuals interested in financing farmers.

Agricultural engineers should be able to give the financiers and the farmers concerned a good idea of the combination of land, structures, and other production facilities, and the scale of operation, which would stand a good chance of paying out in efficient quantity production at low unit cost. The financiers with reasonable safety and opportunity for profit, could provide the capital necessary to introduce agricultural engineering improvements in farm production facilities and methods, into earlier and more widespread application profitable to the farmer as well as the financier and industries supplying those facilities.

Formula for a Better Tractor or Industrial Machine:



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AGRICULTURAL ENGINEERING

VOL. 32 DECEMBER, 1951 NO. 12

The Return-Stack Orchard Heater

Smokeless Combustion Achieved Through the Use of Combustion Products as a Fuel Diluent

By A. S. Leonard

MEMBER ASAE

OBTAINING smokeless combustion in an orchard heater is a particularly difficult problem, because the heater must be of simple design and give reliable operation while burning a low-grade fuel with a relatively short stack. Simple design is necessary because the cost to the grower must be low in order to justify orchard heating economically. Complex design usually results in a heater much more subject to fouling, in one way or another, by the carbonaceous residues which often accompany the burning of low-grade fuel. Reliable operation is necessary because of the large number of heaters needed to protect an orchard, and the adverse conditions under which they are used. The orchard heater must be able to operate on the lower grades of fuel oil because this is the only fuel (except gasoline) available in sufficient quantity to meet the very large but infrequent demand. The relatively low stack is dictated by the fact that a heater with a tall stack may be upset by the strong winds which are experienced occasionally in the orchards (during non-heating periods).

Because of these restrictions, many of the methods employed successfully in other types of heaters to bring about the smokeless combustion of the lower grades of fuel oil cannot be used in the orchard heater. With this knowledge, the work of developing a practical smokeless orchard heater was undertaken at the University of California at Davis.

The Elimination of Smoke Through a Reduction in the Maximum Size of the Particles of Carbon in the Flame. As an initial approach to the problem, a study was made of the conditions under which smoke is or is not formed. It was soon discovered that the differences are in degree rather than in kind. The flame of a kerosene lamp is a good example of this. It may be made to produce smoke or to be smokeless, merely by turning the wick up or down. In either case, the combustion is quite similar and particles of free carbon are present in the flame. The difference is that, with the wick turned up, some of the particles of carbon escape from the flame, while, with the wick turned down, they are all burned to carbon dioxide by the time they have been carried in the upward flowing gases to the top of the combustion zone.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The author: A. S. LEONARD, specialist in the Agricultural Experiment Station, University of California, Davis.

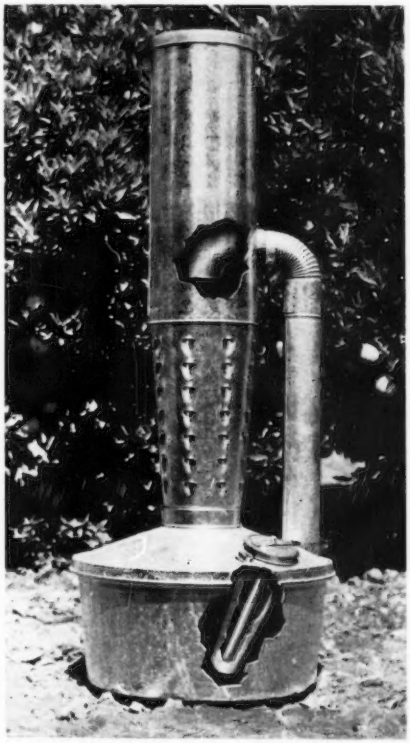

Fig. 1 This picture shows the return-stack heater with portions cut away to show interior details

There are several possible explanations for the particles of free carbon escaping from the flame when the wick is turned up. The particles may grow to a larger size in the flame; the oxygen concentration in the center of the flame may be lower; or the upward velocity of the gases in the flame may be higher. Without some carefully controlled experiments, it would be difficult to tell with any certainty which of these various effects contribute most to the production of smoke by the larger flame. However, the fact remains that, if something can be done to reduce the size of the individual particles of free carbon in the body of the flame, a reduction in smokiness will be obtained. It should be emphasized that this change will be effective regardless of whether or not increased particle size was a contributing factor in making the flame produce smoke in the first place.

The reduction in the smokiness of a flame, brought about by a reduction in the average maximum size of the individual particles of soot within the flame, is the result of two distinctly different effects. First, other things being the same, a small particle of carbon will require less time for its complete combustion than a larger particle. This, however, is not in itself enough to assure smokeless combustion, because if the particle happens to be in a part of the flame which contains very little free oxygen, the time required for its complete combustion may still be relatively long. The second effect is that a small particle will lose heat by radiation more slowly than a larger one and thus will remain longer at a temperature high enough for burning. This very important effect is due to the fact that the absorptive and radiative efficiency of a small particle is very low for light and radiant heat for wave lengths more than about three times the diameter of the particle.

A large black body at 2000 F (a temperature high enough to make amorphous carbon burn rapidly in the presence of free oxygen) sends out over 90 per cent of its radiant energy at wave lengths greater than 1.6 microns. A particle less than about 0.5 micron in diameter will lose heat by radiation very slowly at this or any lower temperature because it is too small to radiate in the longer wave lengths and not hot enough to produce an appreciable amount of radiation in the shorter wave lengths. Most gases are very poor radiators at this temperature.

Combustion products composed of gases and particles of

free carbon no larger than about 0.5 micron in diameter will therefore lose heat by radiation very slowly, and will remain at a temperature high enough for combustion to proceed until they either come in contact with some cooler surface or become mixed with cooler secondary air. If combustion happens to have been arrested temporarily in any particular region of the flame because of a local lack of free oxygen, and if the particles of free carbon grow no larger than about 0.5 micron in diameter, then (barring contact with a cool surface) the products of incomplete combustion will remain at an elevated temperature until they reach a region of the flame where free oxygen, necessary for the completion of combustion is present. Thus, if the particles of carbon in the flame can be prevented from growing to more than about 0.5 micron in diameter, and if the products of incomplete combustion can be kept from coming in contact with cooler surfaces, smokeless combustion is assured.

Gaseous Dilution as a Means of Controlling Carbon-Particle Size in a Fame. In any steady combustion process, fuel and air flow into the flame while products of combustion flow out. As the individual molecules of the fuel get quite close to the flame front, their temperature begins to rise very rapidly. If oxygen, in the form of primary air, happens to have been premixed with the fuel, some of this oxygen may combine with the hydrocarbon molecules during this brief preheating period. However, before more than only a small fraction of the amount of oxygen required for complete combustion can combine with the hydrocarbon molecules, their temperature has reached the point where rapid thermal decomposition or "cracking" takes place. This process sets most of the carbon free in the form of separate atoms — carbon vapor.

BOILING POINT OF CARBON ABOVE FLAME TEMPERATURE

The boiling point of carbon is many thousand degrees above the flame temperature. The carbon vapor in the flame is, therefore, thousands of degrees below its condensation temperature, a fact that will make its condensation extremely rapid. Since the flame temperature is also far below the freezing point of carbon, the carbon will condense into solid particles rather than liquid droplets.

The condensation of a vapor takes place much more readily on a solid or liquid surface than on individual atoms or molecules of the vapor. However, in the absence of such a surface, small groups of atoms, or nuclei, will be formed as the result of multiple collisions between the molecules of the vapor. Once such a nucleus has been formed, the molecules of vapor in its immediate vicinity will be much more likely to condense on it than on each other. As a result of this tendency, the nucleus, once formed, will grow rapidly in size until it has collected most of the condensible atoms and molecules in its immediate vicinity.

If the size of the particles of carbon in the flame is to be controlled, something must be done to retard the rapid growth of the first particles formed and to allow more time for the formation of additional nuclei. The addition of an inert gas to the fuel vapors will do just this. Experiments*, in which hydrocarbon fuels were diluted with such inert gases as nitrogen, carbon dioxide, and water vapor before being burned, have demonstrated the effectiveness of this method of controlling the carbon-particle size. In fact, such smoky fuels as acetylene and benzene can be made to burn with soft transparent flames merely by mixing the proper amounts of any one of these three relatively inert gases with them before they are burned.

Combustion Products Used as a Fuel Diluent. When a hydrocarbon fuel is burned in air, the products of combustion consist almost entirely of nitrogen, carbon dioxide, water vapor, and a little free oxygen. Since each of these gases, with the exception of oxygen, is effective in reducing the smokiness of the flame, it was logical to assume that the mixture would be similarly effective. The first experiments that were conducted at the University of California to test this assumption consisted of introducing some of the products of combustion from one orchard heater into the bowl of a second heater. These experiments demonstrated very clearly the ability of the gaseous products of combustion from the hydrocarbon flame to control the smokiness of combustion when they are mixed with the fuel vapor before it reaches the flame.

Following these experiments, gas-return systems were added to several different makes of commercially produced orchard heaters. These modified heaters demonstrated the feasibility of using a heater's own products of combustion to control its smoke output. In order to arrive at a design which would be less expensive to manufacture, several experimental models were designed and tested. The design which was finally put into commercial production is the University return-stack heater shown in Fig. 1.

The return-stack orchard heater uses the standard 9-gal round bowl which has been in use for many years. The cover is standard except for the addition of the return-tube connector. The combustion chamber and stack are made of galvanized iron and consist of a louvered combustion-chamber section tapering from 6 to 8¼ in in diameter, and a cylindrical stack section 8¼ in in diameter. The return tube is 3 in in diameter and is made of the same material. The gas-return scoop, which extends to the axis of the combustion chamber, is made of cast iron to insure a long life. The standard downdraft tube is used in the bowl to insure quick and easy lighting.

The return-stack heater is lighted with a torch in the usual manner. Unlike other bowl-type orchard heaters, it will burn at all fuel levels with the draft regulator completely closed. The burning rate with the draft regulator closed will vary from about ⅔ to less than ½ gph, depending upon fuel level in the bowl and the depth to which the louvers were punched in the manufacture of the combustion chamber. Higher burning rates can be obtained by opening the draft regulator any desired amount. At all burning rates up to 1 gph, the smoke output of the University return-stack orchard heater does not exceed 1/10 of a gram of carbonaceous material per minute.

Return-Stack Heater Not Fouled by Many Nights of Use. Although some bowl-type orchard heaters are relatively smokeless over a reasonable range of burning rates just after having been cleaned, all except the return-stack heater soon become smoky because of the high rate of soot formation by the pilot flame. This flame must be present within the bowl in order to supply heat for the vaporization of the fuel.

SOOT PRODUCTION HIGH IN ORDINARY BOWL-TYPE HEATER

In any ordinary bowl-type orchard heater, the fuel vapors in the bowl above the liquid fuel are relatively undiluted. The pilot flame is fed by a stream of air surrounded by an atmosphere of fuel vapors. As a result, a considerable fraction of the heat of the pilot flame goes into overheating and cracking the fuel vapors surrounding it. This leads to such a high rate of soot production within the bowl that any stack or combustion chamber—no matter how good it might be when clean—will soon become fouled with soot and its combustion will become smoky. Besides fouling the stack, some of the soot falls back into the fuel in the bowl to form a sludge residue which gradually reduces the effective fuel capacity of the bowl and creates an expensive disposal problem.

The return-stack orchard heater corrects this fundamental defect of ordinary bowl-type heaters. The combustion products which are returned to the bowl by the gas-return system dilute the fuel vapors within the bowl, thus reducing the smokiness of the pilot flame. Also, since the combustion products which are returned to the bowl are quite hot, they assist the pilot flame in vaporizing the fuel. Thus the size of the pilot flame can be smaller for any given rate of vaporization of the fuel. The net result is that soot formation by the pilot is no longer a problem. Return-stack heaters in the field, burned for as long as 180 hr without cleaning, were found to be still in good operating condition.

Other Applications of the Dilution Principle. Although the dilution principle has been in use for many years, it apparently is not well known. The *(Continued on page 663)*

*Some Effects on Inert Diluents on the Combustion of Hydrocarbon Fuels, by A. S. Leonard and L. M. K. Boelter, 1942 Annual Proceedings of the Pacific Coast Gas Assn.

The Oil-Burning Crop Drying Unit

By Vernon H. Baker
ASSOCIATE MEMBER ASAE

THE farm crop drier for drying hay, small grain, corn, and other commodities is rapidly becoming an important piece of equipment on many farms in the United States. Generally speaking, a crop drier consists of an oil burner for heating the air, a fan driven by an electric motor, necessary electrical controls and protective devices, and a flexible duct for connecting the heating unit to the air duct of the drying structure in which the commodity is to be dried. Usually all of these component parts are mounted on a pneumatic-tired trailer to form a complete portable unit; however, in some installations these components may be installed on a permanent base. This discussion is devoted entirely to the oil-burning unit which supplies heat to the commodity to be dried and is not to be a discussion of drying structures such as column driers, batch driers, blanket or tray driers, etc.

There are several crop driers now on the market that are performing satisfactorily and they are constantly being improved through the efforts of equipment manufacturers, farmers, colleges (1, 2)*, U.S. Department of Agriculture (3, 4) and insurance agencies (5). The Committee of Crop Drying Equipment of the American Society of Agricultural Engineers (6) is working with these groups in an effort to develop functional requirements, safety and design standards. The National Fire Protection Association has established a committee on dehydrators and driers (5).

Adequate design standards were unavailable when crop driers were originally developed. Similarly standard test procedures for the different types of driers were unavailable. Consequently some of the first units which came on the market were not well designed and did not have adequate safety devices built into them. General standardized specifications and test procedures are still lacking although some work in this area has been reported by Shedd (3). In view of this condition it is believed that everyone concerned with the farm crop-drying problem would be benefited if a testing procedure and laboratory for the farm crop drier could be established. Some performance tests on crop-drying equipment have been conducted at the University of Illinois (7). It would also be advantageous if standards were adopted for air distribution and temperature level for drying different commodities. This could include, for example, the cubic feet per minute of air per bushel or ton of a commodity and the temperature level that could be employed in order to obtain proper germination of seed, palatable animal feed, and proper milling qualities.

FARM CROP DRIERS

Types of Driers. There are two general types of commercial oil-burning electrical farm crop driers, the direct and indirect. In the indirect type (Figs. 1 and 2) the burned gases or products of combustion pass through a heat exchanger then into a smokestack, allowing only heated air to pass through the commodity to be dried. In the direct type (Fig. 3) the burned gases or products of combustion pass into the heated air that is forced through the commodity to be dried.

Types of Burners. There are two general types of burners, the pressure-atomizing (Figs. 1 and 3) and pot type (Fig. 2). In the pressure-atomizing burner the oil is pumped under pressure to the burner. The rate of burning or temperature obtained with pressure nozzle is controlled by the size of the nozzle and the pressure that is maintained. Oil flows into the circular pot burner and burns at slightly below atmospheric pressure, usually from 0.02 to 0.06 in water column as determined by a draft gage. Draft for the pot burner or atomizing burner may be furnished by the main fan or a separate fan. There is a third type of burner found on some crop driers which is generally classified as a low-pressure industrial burner. With this type both oil and air are forced under pressure to the burner with mixing of oil spray and air taking place just outside of the nozzle. Oil pressure will probably average 100 lb per sq in and air pressure about 4 lb per sq in; however, they are both regulated simultaneously by a modulating motor and thermostat to provide control of output heat.

Fuels. Fuel oil grades of Nos. 1, 2, or 3 are most commonly used in oil-burning electrical farm crop driers. The manufacturers will generally recommend the grade of oil to be used in their burners.

Ignition. Most of the farm crop driers now on the market have ignition transformers with ignition points that produce a spark at all times during the period that the burner is in operation; however, oil in the pot-type burner must generally be ignited with a burning oil-soaked rag or piece of paper placed in the pot burner.

Fan Types. Two types of fans, the centrifugal and propeller, are used with farm crop driers. The propeller type is most commonly used on portable units. Propeller fans, built into a tubular enclosure equipped with vanes to direct the air, are often used. This type of fan equipped with vanes may be operated against higher pressures than the conventional propeller fan. The conventional propeller fan is more efficient if equipped with an orifice ring.

The centrifugal fan is made in two types, the forward and backward-curved blade. The backward-curved fan will not place an overload on the fan motor if the air pressure is reduced, whereas the forward-curved fan may overload the fan motor, if the air pressure is reduced. For the same capacity the backward-curved fan usually costs more than the forward-curved fan since it must be built stronger to operate at a higher speed.

Power. The electric motor is the most satisfactory type of power if electricity is available. With the electrically-operated drier, automatic safety devices may be used. Motors of 3, 5 and 7½ hp, single-phase, 60-cycle, 230 v, capacitor type, repulsion-start-induction-run type and the repulsion-induction type may be used. The fan can be driven directly by the motor or connected to the motor with a V belt and pulley arrangement.

Temperature Controls. A minimum of three temperature controls is necessary. These are an upper-limit thermostat, a temperature-regulating thermostat, and a flame-failure fuel shutoff control. The upper-limit control will cut off the fuel supply if the temperature goes above a certain preset value. The regulating thermostat is generally placed in the air stream that enters the commodity to be dried. In some cases the upper-limit thermostat may be used for the regulating thermostat. The flame-failure control shuts off fuel in case of ignition failure so that the combustion chamber will not be flooded with oil. The flame-failure device may be a reverse-acting thermostat placed in the stack of drier so that if the temperature does not rise after a short-time interval, the oil supply will be shut off; or a photoelectric cell connected to an electronic switch will stop the oil pump in case of flame failure.

OPERATION OF THREE CROP DRIERS

The operation of three different crop-drying units is presented in order to list the component parts of each unit and their function. Most of the crop-drying units now being

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*Numbers in parentheses refer to the appended references.

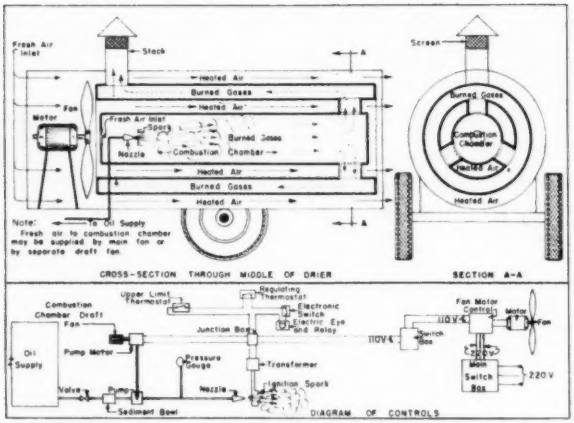

Fig. 1 Crop drier, indirect type with heat exchanger, showing pressure-atomizing burner and controls

manufactured will be either the indirect type with heat exchanger and pressure-atomizing burner, indirect type with heat exchanger and gravity-flow pot burner, and the direct-type with no heat exchanger and with pressure-atomizing burner. These different types of driers will vary somewhat with different manufacturers. Such items as the main fan, controls, etc., are likely to be different, but the over-all operation of most of the different units can generally be grouped under the three units discussed in the following paragraphs:

Indirect-Type with Heat Exchanger and Pressure-Atomizing Burner. In this unit (Fig. 1) fresh air is blown over the heat exchanger into the flexible duct leading to the drying structure. The fan is directly connected to an electric motor. This eliminates the necessity for pulleys and V belts. When the motor is mounted in the stream of entering air, the danger of motor overheating is less. The opening where fresh air is drawn into the fan is covered with a protective screen in order to prevent trash from entering the fan and for safety purposes. Fresh air for the combustion chamber may be supplied by the fan through an opening in the combustion chamber or by a separate electric motor-driven fan. The latter method of supplying air to the combustion chamber has been successful on thousands of domestic-type oil furnaces. The draft created in the combustion chamber forces the burned gases out of the combustion chamber through the heat exchanger and out of the smokestack. (With heat exchanger none of the products of combustion go into air that is circulated through the product to be dried.) The top of the stack is covered with 6 or 8-mesh screen in order to prevent sparks or ignited pieces of soot from being emitted from the stack.

When the drier has been set in place and is ready for operation, the main switch is turned on (Fig. 1), actuating the fan motor control which starts the fan motor and also energizes the circuit to the secondary switch which controls the ignition transformer, electronic switch, motor that drives the oil pump and draft fan. When the secondary switch is closed, the pump motor forces oil to the nozzle and the ignition spark is energized. If a satisfactory flame results after a short delay, the photoelectric cell (or electric eye) through the electronic switch will keep the circuit to the oil pump and ignition transformer operating. If for some reason a satisfactory flame is not created, due to loss in oil pressure, water in oil, etc., there will not be enough light to actuate the photoelectric cell and electronic switch. This will cause the circuit to the oil pump motor and ignition transformer to open. The fire cannot be started until the fault has been corrected. The upper-limit regulating thermostat and electronic switch are connected in series with the circuit that controls the ignition transformer and oil-pump motor. The upper-limit thermostat for most driers is generally set at a safe temperature at the factory. The regulating thermostat is generally located in the air stream before the air enters the commodity to be dried.

Indirect-Type with Heat Exchanger and Gravity-Flow Pot Burner. A sketch of this unit is shown in Fig. 2. Air from the fan is blown past the heat exchanger into the flexible duct that leads to the drying structure. The fan is connected to the electric motor by a V-belt arrangement which allows a number of different speeds to be obtained by varying the pulley sizes.

Oil is supplied to the pot burner by gravity from a tank located above the bottom level of the burner. The oil flows through a tank control valve, a sediment bowl, and then into the electric float valve. The valve controls the amount of oil going into the pot burner and the temperature can be controlled by adjusting the knob on the valve. An adjustable upper-limit thermostat is connected to the float valve so as to limit the maximum temperature obtainable. Air is forced into the combustion chamber either by a small centrifugal draft fan or by the main fan through special openings in the side of the burner. In any event, a draft is created and the burned gases are forced out of the combustion chamber through the heat exchanger and out through the smokestack. The top of stack should be covered with a 6 or 8-mesh screen wire in order to prevent sparks or ignited pieces of soot from being emitted from the stack.

Before placing the drier in operation, it should be leveled; the sediment bowl should be checked to see that no water is in the oil; the drain plug in the bottom of the sediment bowl and burner should be opened to drain off any water or trashy oil, and the temperature-regulating knob on the electric float valve should be set to the desired value. It is then necessary to allow a small amount of oil to be drained into the pot burner and then ignite the burner through a small opening in the side of drier with a special oil-soaked rag on the end of a piece of wire. After the flame in the burner has been started, the main motor switch is actuated. All the electric controls should be connected through the motor start switch so that, should motor failure occur, the entire unit will be shut off.

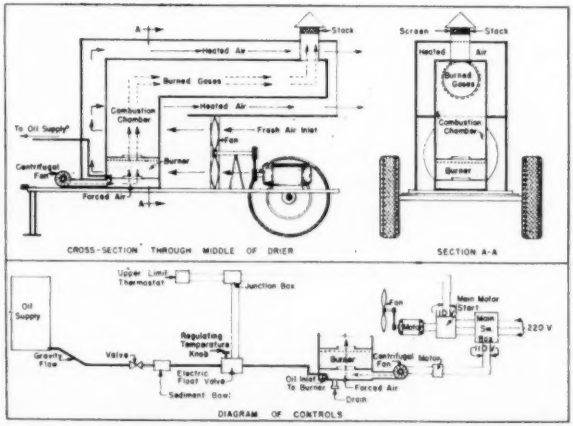

Fig. 2 Crop drier, indirect type with heat exchanger, showing gravity-flow pot burner and controls

Table 1-A - Maximum drying air temperatures for proper seed germination, palatable animal feed, and acceptable milling qualities for commodities listed:**

Commodity	Max °F for seed germination	Max °F for animal feed	Max °F Milling	Reference
Corn	110	190	130	(a) BPISAE, USDA
Wheat	110[a]	*	180 for 40 min.	(b) Birchard, F. J., Canada Dept. Trade & Comm. 1934
Oats	100-120	*	*	North Carolina State College, Raleigh
Barley	110	*	130	(a) USDA
Rice	120	—	130	Kramer, H. A., La. Agr. Exp.Sta.& USDA
Soya Beans	110[a]	270°	270°	(c) Langhurst, L. F., Borden Processing Co., Waterloo, Iowa

** Max. moisture content, air flow and type of drier not generally available.

* Unable to find in literature.

Table 1-B - Maximum drying temperatures, moisture content, type of drier and air flow for good seed germination, Reference - Texas Agric. Expt. Sta.

Crop (Seed)	Max. temp. for good germination deg. F	Max. Moisture content percent	Type drier	Depth inches	Minimum air velocity ft. per minute
Sorghum	160	20	Column	10	90
Flax	160	14	Column	10	80
Rice	125	18	Sack	1 sack	30
Peanuts	125	18	Sack	1 sack	30
Peanuts	135	18	Column	16	80
Rescue Grass	115	50	Column	10	60
Dallis Grass	120	20	Sack	2 sacks	40

Table 1-C - Maximum Drying Temperatures for Commodities Not Listed in Tables 1-A, B

Commodity	Drying Temperature	Reference
Hay	140 F Seems to be a practical temperature; however, outlet air temp. up to 325 F are used in dehydrators	Va. Agric. Expt. Sta. and USDA Cir. 443
Bright Leaf Tobacco	165 F Max. drying temp. range 80 F - 165 F	Va. Agric. Expt. Sta.
Crimson Clover	115 F Blue Lupine 115 F	Ala. Agric. Expt. Sta.
Peanuts	110 F Air flow 60 ft. per min. for seed	Va. Agric. Expt. Sta.

Therefore, simultaneously with the starting of the main motor, the small centrifugal fan for supplying air to the combustion chamber is started and the electric float valve is actuated. Since there is no ignition transformer, it is necessary to relight the burner as described above, if a flame failure occurs. In case of flame failure, the oil will continue to flow into the pot burner until a predetermined level in the burner is reached; then the float valve will trip, cutting off the flow of oil to the burner. If this happens, it is necessary to drain excess oil from the pot burner before relighting it. It would be desirable to have a solenoid valve with suitable controls properly mounted in oil supply line so that when a flame failure occurs the oil supply would be cut off.

Direct-Type with No Heat Exchanger and with Pressure-Atomizing Burner. In this unit (Fig. 3) the gases and products of combustion are forced into the air stream and into the commodity being dried. The fan and oil pump are driven by an electric motor and a V-belt pulley arrangement. Oil flows from the oil-supply tank through a control valve and preferably through a sediment bowl, then into the oil pump and through a valve that is used to regulate the pressure on the nozzle. Oil then flows through an electric solenoid valve, then through a valve that is used to regulate the oil supply to the nozzle.

An ignition transformer supplies a constant spark to the atomized fuel at the nozzle in order to keep the oil ignited at all times when the unit is in operation. Air passes through a screen, then enters the combustion chamber through the air inlet for the burner opening as shown in Fig. 3. The burned gases and products of combustion are blown out through the main air stream into the product being dried. In order for this unit to be satisfactory, it is necessary to have as complete combustion as possible so that no great amount of smoke or soot will be forced into the air stream. This may generally be accomplished by proper regulation of the damper, ignition spark and pressure on the nozzle. The direct type is more efficient than the indirect type with heat exchanger; however, if the direct type is not properly adjusted, the fire hazard is increased.

When the drier has been set in place and is ready for operation, the main switch and motor switch are turned on. This allows the fan motor, electric solenoid valve and ignition spark to operate. The electric solenoid should be connected so that either an excessive temperature or failure to heat will close it. This will insure that the combustion chamber will not be filled with oil in case of improper combustion. There is no upper-limit thermostat shown for this unit. The size of nozzle and type of oil will govern the maximum temperature under fixed conditions.

Safety and Insurance (8). It is not intended to discuss the safety of any one particular manufacturer's equipment. Those manufacturers of crop driers that have been listed by Underwriters Laboratories and are considered safe by the insurance companies are to be commended on their work. Some people say where there is fire there is always a fire hazard. Domestic-type oil burners have been used in dwellings for many years for furnishing heat. Rules and regulations governing the use of these oil burners have been worked out by most all fire insurance companies. The farm crop drier, both the indirect type and the direct type, offer different problems from the domestic oil burner in the home. These units must generally be built for rough handling and for weather exposure. The heated air from those units is usually blown into combustible materials such as hay, grain, etc., in wooden structures. There is a possibility of combustible debris such as straw, shucks, or similar material com-

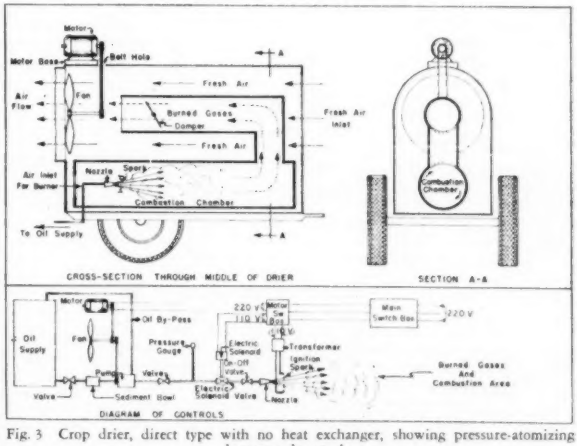

Fig. 3 Crop drier, direct type with no heat exchanger, showing pressure-atomizing burner and controls

ing in contact with the flame, causing fire to start. There is also a possibility that pieces of carbon from the improperly adjusted indirect unit may be blown from the drier into the commodity being dried. However, if the drier is well designed for safe operation, proper management of it is important in determining if it is to be hazardous.

The rules governing the underwriting of farm crop-drying equipment are often ambiguous as they are, in many cases, the results of individual thinking. The fire insurance form used by the majority of the Indiana fire insurance companies contains the following provisions (9): "Unless otherwise provided in writing added thereto, this company shall not be liable for loss occurring while the hazard is increased by any means within the control or knowledge of the insured." Many policies contain an additional statement which refers directly to crop processing as follows: "Artificial heat shall not be used for drying or processing hay, grain or farm products, except by special permit endorsed on this policy." Many insurance companies do not have men who are capable of determining whether a specific drier is safe, and it may be common for an insurance company to refuse liability on risks which utilize driers that are not listed by the Underwriters Laboratories rather than go to the expense of determining whether or not the drier is actually hazardous. When a farmer is contemplating buying a farm crop drier, it would be wise to go over his insurance policy with his agent to be sure that he has proper protection.

Underwriters Laboratories' Approval. It should be the desire of every crop-drying equipment manufacturer to have his equipment listed by the Underwriters Laboratories. In some areas equipment cannot be sold unless it has the Laboratories' approval. Although this approval does not mean that the unit is fireproof, it does illustrate that the company has taken steps and has made considerable effort towards making it safe for farm use.

Just what does Underwriters Laboratories' approval mean? Its approval of a farm crop drier means, as far as the author has been able to determine, that the Laboratories have notified all of the boards of fire underwriters in the various states that they have examined, tested, and passed on the machine and found it to comply with the minimum safe standards of design and construction with regard to fire hazards. Then it is the option of the individual fire underwriting boards in each state to set their insurance rates accordingly. In some states the insurance companies have removed all penalties from policies covering crop driers that have been listed by Underwriters Laboratories, and in other states the premium has been decreased by as much as fifty per cent.

Maximum Drying Temperatures for Different Commodities. There has been considerable work done on desirable drying temperatures for different commodities for optimum germination, acceptable animal feed and proper milling qualities. The data in Table 1-A, B, and C attempts to summarize these temperatures from a number of sources. Distinction should be made between drying in a batch-type drier and a column-type drier, as it is generally the consensus of opinion that a higher temperature may be permitted in the column-type drier than in the batch-type drier. The air velocity and initial moisture content of commodity must also be considered. A summary of moisture, air, and temperature requirements for drying various commodities in the different states has been published by the U.S. Department of Agriculture (10).

Some Desirable Features of a Farm Crop Drier. Some of the following desirable features have already been presented (1, 3). Many of these features are essential as well as desirable. Experience and observations indicate that it would be desirable for crop-drying units and the information describing them to meet these requirements, leaving the specific designs to the ingenuity of the designer and manufacturer. Listing these features is not intended to discredit any manufacturer who does not comply with them, provided he has Underwriter Laboratories approval:

1 All electric wiring should be in accordance with the national electric code, and should be weatherproof and dustproof. All electrical wiring should be completed at the factory. This includes wiring of the main switch box and the motor magnetic starter. The unit should be ready to plug into an appropriate individual equipment outlet.

2 The main fan should be driven by a 3, 5 or 7½-hp, single-phase, 60-cycle, 230-v capacitor-type, repulsion-start-induction-run-type, or repulsion-induction-type motor with a magnetic starter switch and thermal overload protection or the equivalent. The motor should be mounted so as to be protected from the weather.

3 An upper-limit switch, which will shut off the burner immediately if the temperature within the drier exceeds a safe limit, should be provided.

4 A device for stopping the flow of fuel to the burner in case of ignition or flame failure should be included.

5 All safety electrical controls, including spark transformer, electronic switch, electric solenoid valves, etc., should be controlled by the same magnetic switch that controls the main blower motor so that, as the main motor is shut off, the controls for the entire unit will be inoperative.

6 Manufacturers' literature should include recommended fuel grades for each oil burner and show suitable and recommended fuel-supply tanks with proper connection to burner.

7 A sediment bowl and strainer should be supplied for the oil-supply line so that trash, water and foreign matter can be removed before entering the combustion area.

8 The fuel pump and all fuel lines and gauges should be located outside of the heated air stream and away from the combustion chamber to avoid any unnecessary fire hazard (3).

9 Btu rating of each unit should be listed as amount of heat added to the entering air (based on actual tests).

10 If the drier is the heat-exchange type, the heat exchanger should be designed to transfer to the drying air at least 65 per cent of the heat developed by burning fuel (3).

11 The heat exchanger should be of corrosive-resistant material that would withstand the high temperatures of the burner for a period of 5, or even better, 10 years.

12 All air entering the drier and burner should pass through a suitable screen.

13 In listing air output at various static pressures, such listings should be based on the output of the drier as a unit rather than of the fan alone.

14 The fan should be tested and certified by the PFMA fan rating code and should be mounted on the entering air side of the drier.

15 The flexible duct material joining the drier with the drying structure should be fire resistant and durable.

16 Each portable unit should have provisions so that it could be properly anchored to the ground.

17 All component parts of portable driers should be mounted on a trailer with standard pneumatic tires for convenient movement of the drier.

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Calculation and Design of Cutterhead and Silo Blower

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MEMBER ASAE

THE silo blower, in which the material is introduced into the fan casing and pipe through the fan wheel, has become generally accepted today and is used for conveying chopped green fodder from the silage cutter to the silo. The advantages consist of its simplicity and the consequent low price in comparison with mechanical conveyors with chains, and also the possibility of combining the cutting with the blowing by mounting the knives on the fan wheel. The height of conveying which may be reached by this method is sufficient for all silos up to about 60 ft.

The disadvantage of being able to convey only vertically and not horizontally with the silo blower is of little importance. A more important consideration is the higher horsepower requirement compared with mechanical conveyors, this being especially large if the silo blower is not of the correct dimensions. Although the silo blower has been in the process of development for a long time, there are few models in which the power requirement is as low as it might be with correct design and coincidence of cutter output with blower capacity for various heights of silo. Published test reports show differences of power requirements of up to 100 per cent, and in this paper it will be shown by which means the design may lead to reduced power requirements. The data given are based on evidence in accounts of experimental work contained in several former publications.

The following proposals are concerned primarily with silage cutter blowers for filling silos, but are also applicable to forage harvesters embodying a blower which has a high power consumption. Such forage harvesters often need bigger tractors than the farmer can afford, so that the use of this important implement for providing protein feeding stuffs generally is limited to the larger farms.

The working of a silo blower is based on principles very different from those of a fan designed for pneumatic conveying, so that the known and published data for calculations* in connection with fans is not applicable to this kind of conveyor. A pneumatic conveyor which is not suitable for greenstuff will have an exceedingly high power consumption for the air speed obtained, which makes it uneconomical when used as a silage blower. In this type of conveyor the material is introduced into the pipeline by means of special feeders and the full work of conveying is effected by the energy in the high-speed air stream. With the silo blower the material is introduced into the fan casing through the fan wheel, and most of the work of conveying is imparted to the material merely by the throwing effect the wheel has on it, and is accompanied by a low air speed. We may therefore term it an "impeller blower." Obtaining this throwing effect necessitates a different construction both for the blower wheel and for the casing from that of ordinary air fans.

The outstanding points are the low number of blades used (usually two to six) and the form of the casing, which is concentric instead of spiral, with the intention of avoiding blockages. The blades must be as close as possible to the sides of the casing, both radially and laterally†.

The material handled by the blades of the wheel will leave with a speed almost equal to that of the blades — that is to say, with the peripheral speed of the wheel. The air between the blades will have approximately the same speed as the blades, and this is partially transformed into pressure at the exit from the casing, so that the air speed at the bottom of the pipe is less than the speed of the material. The air, therefore, has first the effect, not of conveying, but of braking, in contrast to pure pneumatic conveying, in which the air moves several times as fast as the material and draws it along. Only in the farther part of the pipe does the speed of the material decrease to a value sufficient to avoid blockage. The air speed remains constant so that in the last part of the pipe the air moves faster than the material and delivers a small portion of conveying energy to it. That is the reason why an increased air delivery due to more blades has no beneficial effect on the conveying; it will only increase unnecessarily the power requirement. Since it can be shown by a simple calculation that the quantity of material dealt with by each blade is very small, the number of blades has been reduced in recent years to two, three, or four. If occasionally plugs or balls of the material issue from the end of the pipe, a circumstance which is frequently followed by a complete blockage, this has no connection with a shortage of conveying air. If the blade speed is sufficient, such a blockage may be due to the pipe being too small.

Height of Conveying. Assuming the material on leaving the blades is travelling at the same velocity as the blade tips, the heights of conveying, neglecting friction, would be, theoretically, $H_t = u^2/2g$, where u = the peripheral speed of the blades in feet per second and g = gravitational acceleration. Practically, however, this value is only partially attained on

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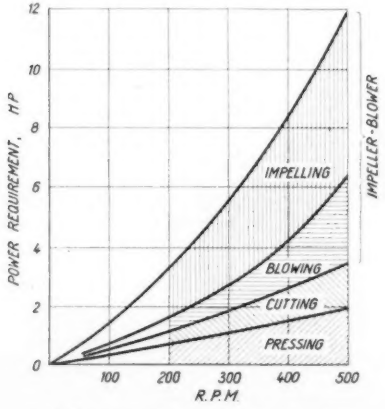

Fig. 1 Power requirement of a silage cutter blower

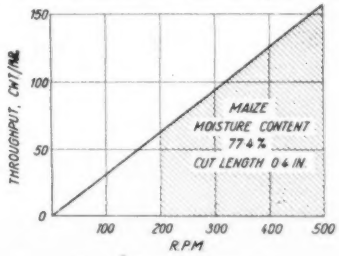

Fig. 2 Throughput (capacity)

account of the deceleration of the material stream in the pipe due to friction in the material stream between one particle and another, friction of the material on the pipe walls, and the braking effect of the air on the material due to its speed being lower than that of the material at the beginning of the pipe.

All these points have a considerable effect on the height of conveying. For instance, the height of conveying will be increased with a decreased quantity of material. Further, the friction in a large pipe has less influence than in a smaller pipe. The height of conveying is governed primarily, however, by the peripheral speed of the fan wheel, so that it is dependent mainly upon the diameter of the wheel and the rotational speed. For each height of conveying and quantity of material, a minimum value for the peripheral speed is necessary. With speeds below this limit blockages will occur, but if the speed be higher than this, the power requirement is increased out of proportion to the work done.

Power Requirement. Of the total power requirement of a silage cutter blower (Fig. 1), the proportion that is required by the blower has been determined experimentally‡. The wheel diameter of the machine tested was 52 in, the number of blades six, and the pipe diameter 10 in. It will be seen from Figs. 1 and 2 that although the throughput varies in direct proportion to the wheel speed, as does also the power requirement for feeding and cutting, the power requirement for conveying does not vary in the same way, but increases more rapidly as the wheel speed increases. In the diagram the conveying portion of power requirement is divided to show the amounts for impelling and blowing. The shape of the curve of the power requirement for conveying follows the equation $HP = u^{1.473}/130.5$, where u is the peripheral speed in feet per second. This equation is only valid for the curve of Fig. 1, and for the machine tested. It shows that the shape of the curve for conveying is not linear but exponential.

By increasing the speed of the wheel, the output of the cutter is increased in direct proportion to the speed. If this is done, there will be an increase in the total power requirement of the whole machine, and this may be an important point for consideration, since the rate of increase in total power requirement is greater than that of the corresponding wheel speed. At the same time, the higher speed will give a greater height of conveying. If this is not utilized, as, for instance, with a low silo, a waste of power will occur, but if, on the other hand, the speed is reduced for a low silo, the full cutter output will not be in use, and it will, therefore, not be operating economically.

The results of the experiments have shown that silage cutters which are designed for high silos, when used for low silos, may work with a waste of 4 hp. Often this figure, however, is greater if fundamental mistakes are made on the dimensions of the blower. It will be shown how such mistakes may be avoided by suitable coincidence of cutter output with conveying capacity.

‡G. Segler: Untersuchungen an Silohackslern, Technik in der Landwirtschaft, 1933, p. 135.

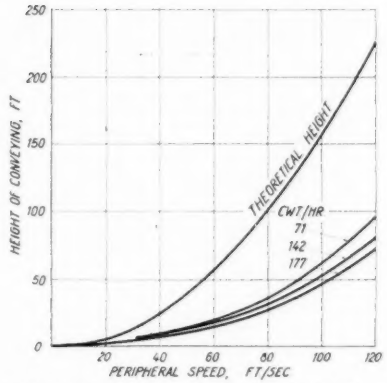

Fig. 3 Comparison of theoretical and practical height of conveying

Design of Impeller Blowers. Data for the design of impeller blowers can be taken from the publications already cited. Results from experiments made with an impeller blower with a wheel diameter of 52 in and a pipe diameter of 10 in, and also with another blower of small diameter, both working with green maize up to throughputs of 180 cwt per hr and for heights of conveying up to 66 ft, have provided information giving the requisite peripheral speeds related to the height of conveying (Fig. 3).

The graph shows that the theoretical height of conveying, $H_t = u^2/2g$, is only partially attained, and to a decreasing extent with increasing throughput and pipe length. A value of zero is assumed for the material velocity at the end of the pipe, but in practice, however, it is necessary for the material to have a certain velocity at the end of the pipe to convey it through a bend which deposits it in the silo. This explains one part of the difference between the practical and theoretical

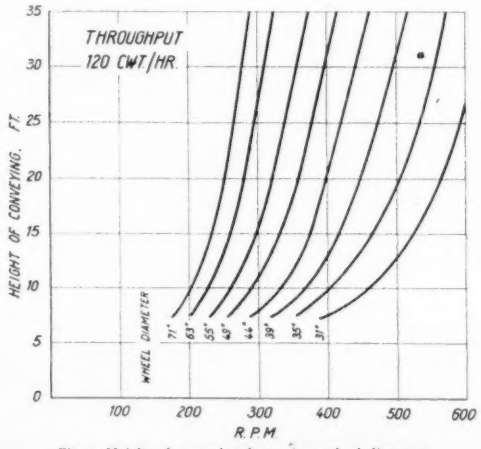

Fig. 4 Height of conveying for various wheel diameters

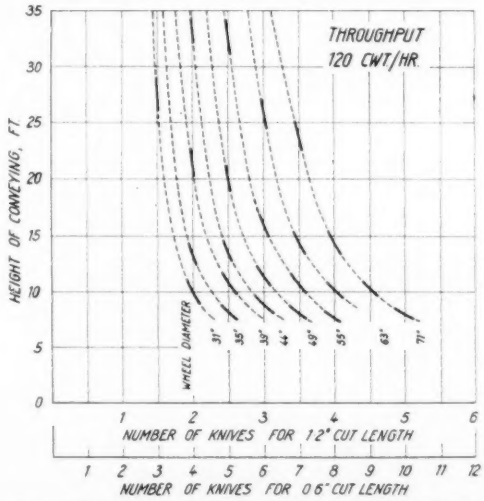

Fig. 5 Relation between wheel diameter, number of knives and cut length

figures in Fig. 3. The figures obtained from the experiments include the bend for the 10-in pipe. For a smaller pipe the figures would be decreased due to greater friction.

From the curves shown in Fig. 3, the following equation for the height of conveying, $H = u^2/2g \times 1.7/\sqrt[3]{W}$, may be derived, where H is the practical height of conveying in feet and W is the throughput in hundredweight per hour§. This equation helps in calculating the peripheral speed for each height of conveying up to 60 ft, but it is necessary to add a small margin of speed in order to allow for fluctuations. The peripheral speed will be

$$u = \sqrt{\frac{2gH}{1.7} \times \sqrt[3]{W}} \text{ (ft per sec)},$$

and the speed for a given wheel diameter $n = 60u/\pi D$, where D is the diameter in feet. In Fig. 4 the rotational speeds for wheels of various diameters, from 31 to 71 in, are plotted against the corresponding heights of conveying. The values for the heights of conveying are valid for a throughput of 120 cwt per hr and include the bend at the end of the pipe through which the material is directed sideways into the silo. This graph makes it possible to determine the minimum value for the blower speed for each height of silo.

Another question the designer must consider arises from the fact that in agriculture it is quite usual to find tower silos of about 30 ft on some farms, and on others structures less than 10 ft high. Most cutter-blowers today are designed for high tower silos. When working at full capacity, their output goes mostly hand-in-hand with the speed that is necessary to reach the requisite height of conveying. However, when using the same machine at a lower silo, at reduced speed in order to avoid a waste of power through an unnecessarily high throwing speed, the output will be decreased in the same proportion as the speed. This decrease in output may be 30 per cent in the example given, and it will be more if the difference between the heights of the silos is greater. The decrease can be avoided by using a faster feed to the machine, resulting in a longer cut length when working with a low silo. This can be effected by a change of gears or sprockets. Generally, however, a longer cut length is undesirable so that in these circumstances more knives should be used in order to obtain the most effective coincidence of cutter output and blower throughput.

The solution lies in the arrangement of the correct number of knives for the height to which the material is to be conveyed, and may be determined by a definite calculation which avoids the element of guesswork involved hitherto. Below an attempt is made to show the method by which the calculation is arrived at.

The cutter output may be calculated‖ from $W = bhlNnk/60$ (cwt per hr), where b = the width of the throat in feet

h = the height of the throat in feet

l = the cut length in inches

N = number of knives

n = revolutions per minute of the wheel

k = a constant, to be obtained from experiments involving the degree of filling of the trough, the degree of compaction, and the specific weight of the material.

k was found to be 0.00012** from test results††. This relationship makes it possible to find, for a given throughput and given dimensions of throat, as well as for a given cut length and number of knives, the necessary speed of the wheel, or for a given speed the number of knives.

A cutter blower with a capacity of 120 cwt per hr, throat width 10 in, and throat height 5 in, has been taken as an example, and the results in Figs. 4 and 5 show, for various wheel diameters and for corresponding heights of conveying, the numbers of knives from two to five for a cut length of 1.2 in, and from four to ten for a cut length of 0.6 in. An example will show the use of these graphs.

The desired height of conveying is 36 ft. For two knives, and 1.2 in cut length, a diameter of 44 in is given and for three knives one of 63 in with the corresponding wheel speeds of 460 and 320 rpm. However, for a height of conveying of 10 ft, i.e., with a lower silo, for the same diameters of 44 in and 63 in, the figures of three and four are obtained for the number of knives required with wheel speeds of 300 and 200 rpm, respectively. This illustrates the valuable fact that it is possible to work with the same machine on both high and low silos, without wasting any power, by using a different number of knives. In the above example, for a diameter of 44 in, two knives for a high and three for a low silo, and for a diameter of 63 in, three and four knives, respectively, are the correct solutions.

It is of considerable advantage to the manufacturer to be able to use the same wheel diameter for all his machines, varying only the number of knives to suit the particular silos at which each machine will be used. Although in the above example two possible sizes of wheel, 44 in and 63 in, were found, the latter may be rejected as being inconveniently large. It is an interesting fact that there are, therefore, optimum dimensions for a particular machine. A similar calculation may be made for a higher throughput of, for instance, 180 cwt per hr. Results for higher throughputs which are not given here show very little variation from those for a throughput of 120 cwt per hr, so that dimensions for the higher rates may be taken from Figs. 4 and 5 without incurring any appreciable error.

If a comparison is made with the aid of these graphs of the performances of present-day commercial machines, it is surprising to see that many of them operate uneconomically. The consequence is that with such a high power consumption the cost of silo filling is greater than it need be. Published test results show that today there are only a few machines that fulfill the conditions laid down above, and that if more attention were given to their correct design and use, further ways would be open for the improvement of these machines.

§This empirical equation can be used for throughputs from 10 to 180 cwt per hr. It is interesting that a similar relationship was found for impeller blowers for grain for which $H = u^2/2g \times 1.65 \sqrt[3]{W}$.

‖This formula was given by F. W. Duffee.

**Duffee gives $k = 0.00036$ for maize. The value 0.00012 for k in the test was for a grass mixture.

††Gorsler and von Ow: Vergleichsprufung von Silierungsmaschinen, Technik in der Landwirtschaft, 1934, vol. 8 and 9.

Return-Stack Orchard Heater

(Continued from page 656)

familiar kerosene lantern is a good example of a burner which uses its own combustion products to dilute the fuel vapors and thus control the smokiness of its flame. In this device some of the combustion products enter the gas-return system above the glass chimney, pass down through the hollow tubular frame at the sides, and are delivered to the base of the flame. In this burner the goal is to control closely the size of the carbon particles. If the particles are too small, the flame will not radiate enough light; if the particles are too large, smoke will result. Use of the combustion products in this application allows the flame to be turned up much higher without smoking than would be possible otherwise.

Early in the development of the steam-atomizing oil burner, it was recognized that the steam used to atomize the fuel also contributed to the clean, smokeless combustion often obtained with these burners. In later years it was found that steam, when introduced into the firebox of a coal furnace, would greatly reduce, or completely eliminate, the soot and smoke frequently obtained from the combustion of this fuel.

Early in the development of oil burning on a commercial scale, it was discovered that flue gases had the same effect as steam on the combustion of oil. There are many designs of furnaces and burners in which a strong internal circulation of combustion products is created and maintained. In these furnaces some of the combustion products circulate within the firebox to the point where the air and fuel are introduced and become mixed with these constituents before they reach the combustion zone. These burners, *(Continued on page 664)*

A Prefabricated Refrigeration Assembly

By U. F. Earp and W. C. Wheeler
MEMBER ASAE MEMBER ASAE

INSTALLATION of refrigeration equipment in two-compartment, walk-in refrigerators may be greatly simplified and expedited by the proper use of prefabricated assemblies. The prefabricated units may be obtained by shop assembling the condensing unit, evaporator, and accessories on an insulated panel, charging, and then testing the assembly before it is taken to the farm. Little time then would be required to make the final installation on the farm. With this system, essentially all of the work can be done in the refrigeration serviceman's shop where proper tools and equipment are readily available. Therefore, the system is conducive to the efficient utilization of labor and to better workmanship.

Recognizing the need for such a unit, one was designed, constructed and tested for possible use in the frozen food section of a two-compartment, walk-in farm refrigerator. It was installed in an experimental refrigerator having a frozen food compartment 27 in deep by 66 in wide by 75 in high, with 12 in of mineral wool insulation on all sides except one of the 66 x 75-in sides which is a partition between the frozen food section and the chill room. This partition has 6 in of insulation except in that part taken up by the doorway.

The unit (Fig. 1) is self-contained and was designed to operate from the 115-v electric supply. It consists of (a) the ¼-hp condensing unit, (b) the evaporator made up of four 22 x 48-in freezing plates, (c) the drier coil which was fabricated from about 35 ft of 0.5-in OD copper tubing, and (d) a properly insulated vapor-protected panel. In addition to these, there are suitable frames for mounting the condensing unit and the evaporator, and there are also the necessary accessories and controls.

The unit was designed to freeze a maximum load of approximately 30 lb of product in not more than 12 hr when the average ambient temperature is 90 F. It was also designed to maintain suitable storage conditions in the compartment while freezing this quantity of product.

Tests and Results. Approximately a year of operation of the experimental refrigerator shows that the assembly has performed satisfactorily. Since considerable emphasis often is placed on freezing rates, a large number of freezing tests were conducted. The freezing load consisted of 28.8 lb of tap water in cellophane-lined cardboard packages having nominal dimensions of 5¼ x 5¼ x 2¼ in. The packages were always placed flat so as to give the largest area in contact with the freezing plate, and they were always frozen on the top plate of the evaporator assembly. A typical curve indicating the rate of freezing is shown in Fig. 2. The arithmetic average of the time required to reduce the temperature of the package at the center of the freezing plate from 70 F to 10 F for 25 test runs was 9.03 hr, with a minimum of 7.8 hr and a maximum of 10.66 hr.

Temperatures in the storage compartment air and in the storage load were observed throughout the tests. A typical curve representative of the storage load conditions is shown in Fig. 2. In only one case did the storage load warm up to as much as plus 1 F, and then for a short period only. By the end of the 24-hr run the temperature had dropped to minus 1 F. Normally the storage load had a temperature of 0 F to −4 F, even while the tests were in progress.

The electrical energy used during the 24-hr tests varied from 6.20 to 7.49 kw-hr with an arithmetic average for all tests of 6.61 kw-hr.

Total running time of the condensing unit varied from 81.4 to 97.7 per cent with an arithmetic average for all 25 runs of 87.1 per cent.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors: U. F. EARP, associate agricultural engineer, Virginia Agricultural Experiment Station, Blacksburg, and W. C. WHEELER, formerly research assistant in agricultural engineering, Virginia Station, now associate professor of agricultural engineering, University of Tennessee, Knoxville.

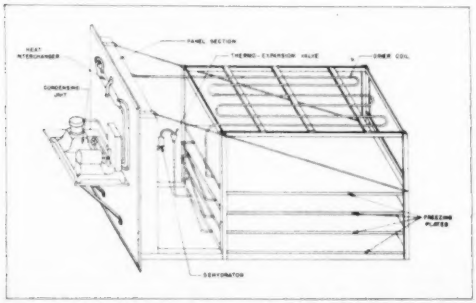

Fig. 1 A pictoral sketch indicating the main components of the prefabricated refrigeration assembly

Return-Stack Orchard Heater

(Continued from page 663)

therefore, make use of the dilution principle without having an external gas-return system.

In some recent experiments with several obsolete types of orchard heaters, to which gas-return systems were added, very satisfactory performance was obtained as far as smokeless operation was concerned. In another experiment, a gas-return system was installed in a pot-type oil-burning home heater. Greatly improved performance was reported for this burner.

From these reports it is apparent that the premixing of some of the combustion products with the fuel before it reaches the combustion zone is a practical and effective method of reducing and controlling the smokiness of combustion of a hydrocarbon fuel. Furthermore, this method of smoke control is applicable to a wide variety of fuels and burners. This suggests that the dilution principle might be applied successfully to a great many different types of burners which otherwise would produce objectionable amounts of smoke.

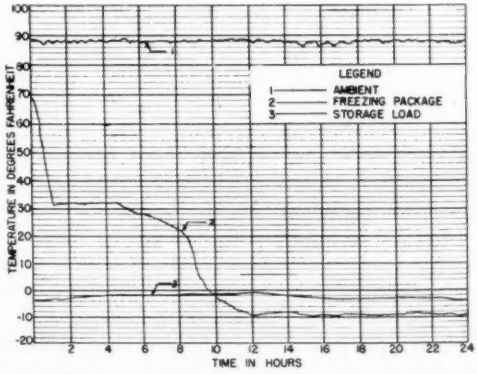

Fig. 2 These curves represent typical operating conditions encountered with the prefabricated refrigeration assembly

Irrigation Requirements of Crops

By Harry F. Blaney
MEMBER ASAE

SINCE water is the limiting factor in the expansion of agricultural areas of the West, the determination of irrigation requirements of various crops and conservation of existing water supplies are of greatest importance in the economy of this area. Considerably more land with soils suitable for irrigation is available for development than there is water with which to irrigate it. Savings in irrigation seldom exist where water is plentiful but where it is scarce conserving methods are the rule; wasteful practices are avoided, and water is carefully applied. The most economical use of water generally prevails where there is a diminishing supply and the cost of water is high. Under these conditions economy in irrigation methods, involving a better understanding of the water requirements of agricultural plants, will benefit all irrigated areas.

The design and construction of irrigation systems usually involve consideration of either of two sets of conditions. In one the area to be irrigated has been determined and the water supply is ample; in the other the known water supply is limited, while the area which may be irrigated is restricted only by the available water. In both cases the total quantity of water to be considered by the engineer is the irrigation requirements of the crops combined with transmission and other losses in canals.

The expressions "irrigation requirement," "water requirement," and "consumptive use," as used in this paper, are defined below to avoid confusion resulting from the frequent but mistaken assumption that they are synonymous. The irrigation requirement is the quantity of water, exclusive of precipitation, that is required for crop production. It includes plant transpiration, evaporation, deep percolation and other economically unavoidable wastes. The water requirement of the crop is the quantity of water, regardless of its source, required by a crop for its normal growth under field conditions. It includes plant transpiration, evaporation, deep percolation and other economically unavoidable wastes. Consumptive use in the quantity of water transpired and evaporated from a cropped area.

Data available on irrigation water use may be divided into three groups. First, irrigation requirements for principal crops have been determined in some areas through research studies by state and federal agencies, frequently in cooperation with the Research Division of Irrigation and Water Conservation, Soil Conservation Service, U.S. Department of Agriculture. Such data are based on soil moisture studies and measurements of depth of irrigation water applied to field plots. The second group of data includes records of depth of water applied (duty of water) in ordinary irrigation practice, estimated irrigation requirements by engineers and experienced superintendents of water companies. The third group includes consumptive use of water by crops as determined by soil moisture studies, tanks (or lysimeters), analysis of climatological and irrigation data or other methods.

For areas for which few or no measurements of use of water are available irrigation requirements of crops may be estimated from climatological and other data by a method developed by the Research Division of Irrigation and Water Conservation, Soil Conservation Service (1)*.

Factors Affecting Use of Water.. Many factors operate singly or in combination to influence the amounts of water consumed by plants. Their effects are not necessarily constant but may differ with locality and fluctuate from year to year. Some involve the human factor; others are related to the natural influences of the environment.

The more important of the natural influences are climate, water supply, soils and topography. The climatic factors that particularly effect consumptive use are precipitation, temperature, humidity, wind movement and growing season.

The amount and rate of precipitation may have a pronounced effect on the amount of water consumptively used during any summer. Under certain conditions, precipitation may be a series of frequent, light showers during the hot summer. Such showers may add little or nothing to the soil moisture for use by the plants through transpiration.

The rate of consumptive use of water by crops in any particular locality is probably affected more by temperature than by any other factor. Abnormally low temperatures may retard plant growth and unusually high temperatures may produce dormancy.

Evaporation and transpiration are accelerated by days of low humidity and slowed during periods of high humidity. If the average relative humidity percentage is low during the growing season, a greater use of water by vegetation may be expected.

Research and Other Data Available. Research studies have been made of irrigation requirements, evaporation from soil and evapo-transpiration by federal, state, and other agencies at various times during the past fifty years. However, there are many areas where little or no data on water requirements are available.

One of the first studies in

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Houston, Tex., June, 1951, as a contribution of the Soil and Water Division.

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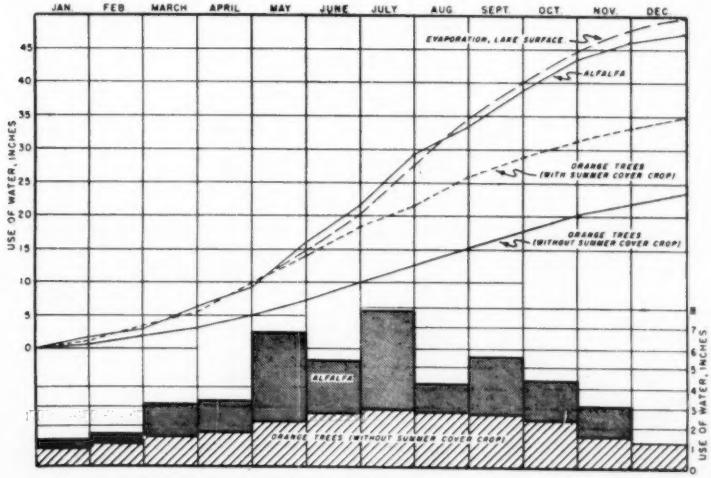

Fig. 1 Monthly use of water in the San Fernando Valley, Calif.

*Numbers in parentheses refer to the appended references.

California (7) of evaporation losses in irrigation and water requirements of crops was made in 1903 by Irrigation Investigations, Office of Experiment Stations, U.S. Department of Agriculture. At various times since that date this agency, now known as the Division of Irrigation and Water Conservation, U.S. Soil Conservation Service, has studied and measured water use by different agricultural crops and natural vegetation in many sections of the West, in cooperation with state agricultural experiment stations, state engineers, and other agencies (2, 3, 12).

An example of the results of a research study by Blaney and Stockwell is shown in Fig. 1. This illustrates the difference between use of water by alfalfa, orange trees with and without a cover crop, and evaporation from a free water surface in San Fernando Valley, California (14). Some of the results of research studies in Arizona, Colorado, New Mexico, Texas, Utah, and other states have been published in government and state bulletins (5, 6, 11).

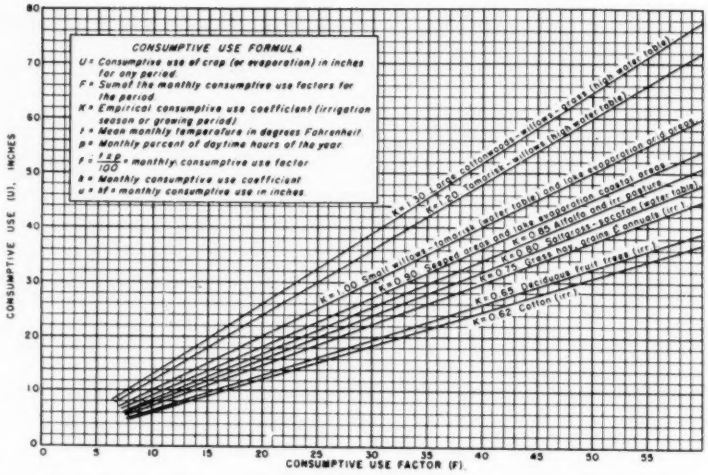
CONSUMPTIVE USE FORMULA
U = Consumptive use of crop (or evaporation) in inches for any period
F = Sum of the monthly consumptive use factors for the period
K = Empirical consumptive use coefficient (irrigation season or growing period)
t = Mean monthly temperature in degrees Fahrenheit
p = Monthly percent of daytime hours of the year
f = t p / 100 = monthly consumptive use factor
k = Monthly consumptive use coefficient
u = kf = monthly consumptive use in inches
K = 1.20 Large cottonwoods - willows - grass (high water table)
K = 1.20 Tamarisk - willows (high water table)
K = 0.90 Alfalfa and irr. pasture
K = 0.80 Saltgrass - sacaton (water table)
K = 0.75 Grass hay, guava & pineapple (irr.)
K = 0.65 Deciduous fruit trees (irr.)
K = 0.62 Cotton (irr.)
K = 0.90 Small willows - tamarisk (water table) and lake evaporation
K = 0.90 Peppers grass and lake evaporation coastal grass
CONSUMPTIVE USE (U), INCHES
CONSUMPTIVE USE FACTOR (F)

Fig. 2 Relation of the consumptive use of water to temperature and per cent of daytime hours

A series of bulletins prepared by Fortier and Young of the Division of Irrigation staff, summarizing results of studies on irrigation requirements in the Great Basin, Missouri River, Columbia River, Pacific Slope basins, and the Southwest were published by the U.S. Department of Agriculture from 1925 to 1933 (8, 9, 10).

A large part of the data presented in these reports are net irrigation requirements of crops determined by experiments on field plots. In some instances the figures shown should be revised to include unavoidable losses such as surface runoff and seepage from ditches before using them to estimate the irrigation requirements for the average farm. The results of some of the net irrigation requirements suggested in these bulletins are summarized in Table 1.

Method of Estimating Irrigation Requirements. In working out farm-planning programs for soil conservation and irrigation districts for which few or no measurements of water requirements are available, it is usually necessary to estimate consumptive use and irrigation requirements of crops from climatological and irrigation data. A method for making such estimates has been develped by Blaney and Criddle (1).

The procedure is to correlate existing consumptive-use data for different crops with monthly temperature, per cent of daytime hours, precipitation, frost-free (growing) period, or irrigation season. The coefficients so developed are used to transpose the consumptive-use data for a given area to other areas for which only climatological data are available. The net amount of irrigation water necessary to satisfy consumptive use is found by subtracting the effective precipitation from the consumptive water requirement during the growing or irrigation season. This net requirement, divided by the irrigation efficiency, indicates the seasonal irrigation requirement of the crop.

Consumptive Use of Water. As previously indicated, consumptive use of water is affected by numerous independent and related variables; and of the climatic factors affecting plant growth, temperature and precipitation undoubtedly have the greatest influence. Furthermore, records of temperature and precipitation are far more universally available throughout the western states than are data for other factors. The actual hours of sunshine also play an important part in the rate at which plants grow and consume water, but sunshine records are not generally available. The theoretical daytime hours for each day are available for all the latitudes (13) and may be used in place of the actual data. Although it is recognized that these may be misleading in areas where heavy fog

TABLE 1 TYPICAL EXAMPLES OF AVERAGE SEASONAL NET IRRIGATION REQUIREMENTS SUGGESTED BY FORTIER AND YOUNG FOR VARIOUS SUBDIVISIONS OF THE WEST
(1925 to 1933)

Location	Season	Net irrigation requirements* acre-feet per acre	Authority
Columbia River Basin			*Fortier and Young*
Snake River Valley, Idaho	Apr-Oct	2.5	U.S. Dept. Agric.
Southwestern Idaho	Apr-Oct	1.9	Tech. Bul. No. 200
Northeastern Oregon	Apr-Sep	2.0	(October, 1930)
Central Oregon	May-Aug	2.4	
Yakima and Wenatchee Rivers, Washington	Apr-Nov	2.6	
Lower Basin, Washington	May-Sep	1.3	
Great Basin			*Fortier*
Bear River Basin, Idaho-Utah	May-Oct	2.0	U.S. Dept. Agric.
Serier River Basin, Utah	May-Oct	2.1	Dept. Bul. No. 1340
Owens & Mono Valleys, Calif.	Mar-Oct	2.1	(October, 1925)
Truckee and Carson Basins, Nev.	May-Oct	2.1	
Humbolt, Quinn & White Rivers	May-Sep	2.0	
Pacific Slope Basins			*Fortier and Young*
Upper Rogue River Basin	Mar-Sep	1.5	U.S. Dept. Agric.
Sacramento Valley	Mar-Oct	2.1	Tech. Bul. No. 379
Salinas River Basin	Mar-Oct	1.7	(Sept., 1933)
San Joaquin Valley	Feb-Oct	2.3	
Los Angeles and Orange Counties	Jan-Dec	1.7	
San Diego County	Jan-Dec	1.4	
Missouri and Arkansas River Basins			*Fortier*
Central Montana	May-Aug	1.7	U.S. Dept. Agric.
South Central Colorado	Apr-Oct	2.1	Tech. Bul. No. 185
Western Kansas	Apr-Oct	1.8	(June, 1930)
Western Nebraska	Apr-Oct	2.0	
Western South Dakota	May-Oct	1.5	
Southwest Area			*Fortier and Young*
Upper Colorado River	Apr-Sep	1.7	U.S. Dept. Agric.
Southern Nevada	Jan-Dec	2.9	Tech. Bul. No. 185
Southern Arizona	Jan-Dec	3.0	(June, 1930)
Imperial Valley, Calif.	Jan-Dec	3.1	
Pecos River Basin	Mar-Nov	2.4	
West-Central Texas	Jan-Dec	1.6	
Lower Rio Grande, Texas	Jan-Dec	1.8	

*Average net requirements of the farm in a crop-growing season. This quantity is exclusive of transmission and other losses which may occur between the source of water supply and the farm.

or stormy weather exists during a large part of the year, temperatures tend to correct for such a condition. Humidity records, if available, may also be used as a correction (4).

Disregarding the unmeasured factors, consumptive use varies with the temperature, daytime hours, and available moisture (precipitation, irrigation water, or natural ground water). By multiplying the mean monthly temperature, t, by the monthly per cent of daytime hours of the year, p, there is obtained a monthly consumptive-use factor, f. It is assumed that the consumptive use varies directly as this factor when an ample water supply is available. Expressed mathematically

$$U = KF = \text{sum of } kf$$

where U = consumptive use (or evapo-transpiration) in inches for any period

F = sum of the monthly consumptive-use factors for the period (sum of the products of mean monthly temperature and monthly per cent of daytime hours of the year)

K = empirical consumptive-use coefficient (growing period)

t = mean monthly temperature, in degrees Fahrenheit

p = monthly per cent of daytime hours of the year

$f = (t \times p)/100$ = monthly consumptive-use factor

k = monthly consumptive-use coefficient

$u = kf$ = monthly consumptive use in inches.

The consumptive-use factor, F, for any period may be computed for areas for which monthly temperature records are available. Then by knowing the consumptive-use coefficient, K, for a particular plant in some locality, an estimate of the use by the same vegetation in some other area may be made by application of the formula $U = KF$. A report published by the Soil Conservation Service (1) assembles the results of calculated normal monthly consumptive-use factors, f, and average monthly precipitation, r, for various areas in the western states, from which the seasonal factor, F, can be determined for any period. The monthly per cent, p, of daytime hours of the year for various latitudes can be computed from Sunshine Tables published by the Weather Bureau (1, 13).

The consumptive-use coefficient, K, has been computed by the formula $K = U/F$ for important crops in various localities of the West (1). The computed coefficients varied somewhat because of the diverse conditions (such as soils, water supply and methods) under which the studies were conducted. These coefficients were adjusted, where necessary, after the data were analyzed. The resulting coefficients, believed to be suitable for normal conditions, are presented in Table 2. Fig. 2 shows the relation of consumptive use, U, consumptive use factor, F, and coefficient, K, for various crops and native vegetation. Further studies may varify or modify these coefficients. In areas where additional data are available, the farm planner or technician can compute consumptive-use coefficients to fit local conditions.

TABLE 2 CONSUMPTIVE-USE COEFFICIENTS, K, FOR IRRIGATED CROPS IN WESTERN STATES (1)

Crop	Length of growing season or period	Consumptive-use coefficient, K*
Alfalfa	Between frosts	0.80 to 0.85
Beans	3 months	.60 to .70
Corn	4 months	.75 to .85
Cotton	7 months	.60 to .65
Flax	7 to 8 months	.80
Grains, small	3 months	.75 to .85
Grain sorghums	4 to 5 months	.70
Orchard, citrus	7 months	.50 to .65
Orchard, walnuts	Between frosts	.70
Orchard, deciduous	Between frosts	.50 to .65
Pasture, grass	Between frosts	.75
Pasture, Ladino clover	Between frosts	.80 to .85
Potatoes	3½ months	.65 to .75
Rice	3 to 5 months	1.00 to 1.20
Sugar beets	6 months	.65 to .75
Tomatoes	4 months	.70
Truck — small	3 months	.60

*The lower values of K are for coastal areas, the higher values for areas with an arid climate.

Irrigation Requirements. A major use of basic consumptive-use data is in estimating the water requirement of existing or proposed irrigation projects and in determining the amount of water required for crop production on individual farms. The amount of water required for irrigation is dependent not only on consumptive use but also on the irrigation efficiency, usable summer precipitation, soil moisture contributed by winter rains, and ground-water contribution. In some areas it is necessary to preirrigate before a crop is planted. In other areas there may be sufficient moisture from precipitation to start plant growth or it may be necessary to irrigate the first time shortly after planting.

Consumptive use of any crop may be estimated from the local consumptive-use factor for the growing or irrigation season and the coefficient for the crop, with allowance for abnormal conditions.

Although a knowledge of consumptive use is important in the case of a large irrigation project, and especially a river system as a whole, it may not be as important to the individual farm as the efficiency with which the water is distributed and applied, especially on a long shoestring project. Irrigation authorities have estimated that in some areas less than one-fourth of the water diverted from the source actually becomes available for use by the plant.

Irrigation efficiency is the percentage of irrigation water that is available for consumptive use by crops. When the water delivered is measured at the farm headgate, it is called "farm" irrigation efficiency; when measured at the field or plot, it may be designated as "field" irrigation efficiency.

The consumptive requirement of irrigation water is dependent not only on the amount of water consumed by the crops but also on the amount supplied by precipitation, winter soil-moisture carry-over, and natural ground-water contribution. After each of these factors is given consideration, the net amount of irrigation water that must be supplied for consumptive use of the crop can be determined. However, this is not the amount of irrigation water required for a farm or even a field, since the water cannot be applied without some loss, regardless of the method used. Generally, not more than 60 per cent of the water delivered at the upper end of the farm is made available for the consumptive use of the crops. The balance is either lost in conveyance to the field, on the field itself through deep percolation, or through surface runoff from the field. Irrigation efficiencies must therefore be taken into account in estimating the irrigation water requirement of the crop. A range of efficiencies for several site conditions is given in Table 3.

TABLE 3 TYPICAL WATER-APPLICATION LOSSES AND IRRIGATION EFFICIENCIES FOR DIFFERENT SOIL CONDITIONS (1)

	General soil type		
	Open porus, per cent	Medium loam, per cent	Heavy clay, per cent
Farm-lateral loss	15	10	5
Surface-runoff loss	15	15	30
Deep percolation loss	35	15	5
Field irrigation efficiency	50	70	65
Farm-irrigation efficiency	35	60	60

Application of Method. The amounts of water required to irrigate an individual crop, a single farm, or an entire irrigation project may be estimated by the procedure previously described. The method and analysis of data are illustrated in Tables 4 and 5. Table 4 shows the calculation necessary to determine the monthly consumptive factors, f, from per cent of daytime hours, p, and monthly temperatures, t, at Plainview, Tex.

In some farm-planning programs it is necessary to estimate

TABLE 4 EXAMPLE OF OBSERVED MONTHLY TEMPERATURES AND PRECIPITATION AND CALCULATED CONSUMPTIVE FACTORS, PLAINVIEW AREA, TEXAS

Month	Mean temperature, t	Per cent daytime hours, p	Consumptive use factor, f	Average precipitation, r, in	Irrigation season and crop: Alfalfa, irrig. pasture-cotton 4/1 f	Alfalfa, irrig. pasture-cotton 10/31 r, in	Sorghums 4/1 f	Sorghums 8/31 r, in	Grain, small 4/1 f	Grain, small 6/30 r, in
Jan	40.9	7.10	2.90	0.42						
Feb	43.3	6.91	2.99	.72						
Mar	50.8	8.36	4.25	.83						
Apr	59.2	8.80	5.21	1.92	5.21	1.92	5.21	1.92	5.21	1.92
May	67.5	9.72	6.56	2.58	6.56	2.58	6.56	2.58	6.56	2.58
Jun	75.6	9.70	7.33	3.04	7.33	3.04	7.33	3.04	7.33	3.04
Jul	78.2	9.88	7.73	3.22	7.73	3.22	7.73	3.22		
Aug	77.4	9.33	7.22	2.74	7.22	2.74	7.22	2.74		
Sep	71.2	8.36	5.95	2.71	5.95	2.71				
Oct	61.0	7.90	4.82	2.08	4.82	2.08				
Nov	49.9	7.02	3.50	1.14						
Dec	40.8	6.92	2.82	.77						
Total		100.00	61.28	22.17	44.82	18.29	34.05	13.50	19.10	7.54

irrigation requirements of each crop at the point of water delivery to the field. This may be accomplished by dividing consumptive use minus precipitation by field irrigation efficiency, as shown in Table 5. For example, the irrigation water required to satisfy the consumptive use of alfalfa is (38.1 − 18.3) or 19.8 in. Assuming a field irrigation efficiency of 70 per cent, then $19.8 \div 0.70 = 28.3$ in, the amount of irrigation water that would be required at the field for the season April 1 to October 31. This is equivalent to 2.36 acre-feet per acre. By making an allowance for conveyance loss from the farm headgate to the field, the amount of water that should be delivered to the farm headgate to irrigate the alfalfa adequately may be estimated.

The irrigation water required to satisfy consumptive use by each crop growing or to be grown on a farm is obtained by subtracting the effective rainfall from consumptive-water requirements during the growing or irrigation season. This net consumptive requirement (consumptive use minus precipitation) of the crop when divided by the farm-irrigation efficiency, gives the seasonal amount of water required at the farm headgate for each acre of the crop. The summation of the headgate requirements for each crop, times its acreage, gives the total amount of water that must be delivered to the farm headgate for satisfactory crop production. To this total must be added the amount of water needed for incidental farm operations.

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TABLE 5 EXAMPLE OF COMPUTATIONS OF SEASONAL CONSUMPTIVE USE AND IRRIGATION REQUIREMENTS FOR CROPS IN THE PLAINVIEW AREA, TEXAS

Culture	Irrigation season	Consumptive-use factor, f	Consumptive-use coefficient, K	Consumptive use, U, in	Net irrigation, $U-R$, in	Field irrig. effic., E, %	Irrig. requirement, I, in
Alfalfa and irrig. pasture	4/1—10/31	44.82	0.85	38.10	19.81	70	28.3
Cotton	4/1—10/31	44.82	.62	27.79	9.50	65	14.6
Sorghum	4/1—8/31	34.05	.70	23.84	10.34	65	15.9
Small grain	4/1—6/30	19.10	.80	15.28	7.74	65	11.9
Seeped land	4/11—11/1	43.10	.80	34.48	16.91	—	—
Natural vegetation	4/11—11/1	43.10	1.20	51.72	34.15	—	—

$U = KF$ = Consumptive use for growing or irrigation season

K = empirical consumptive-use coefficient determined experimentally (see Table 3)

F = sum of monthly consumptive-use factors, f, for the growing or irrigation season

R = sum of monthly precipitation for growing or irrigation season

$I = (U-R)/E$ = irrigation requirement at head of the field.

Drainage of Irrigated Lands in the Lower Rio Grande Valley of Texas

By Morris E. Bloodworth and P. Earl Ross
MEMBER ASAE MEMBER ASAE

THE improper use and management of irrigation water is causing a serious drainage problem in many irrigated sections of the Lower Rio Grande Valley. Crop yields have been reduced at an alarming rate during the past few years; consequently there is an increasing demand for information on the proper techniques and methods to be used in the drainage and reclamation of those lands that are affected by high water tables and salinity.

The climate is semitropical with practically a year-long growing season. Rainfall varies from over 30 in on the coast near Brownsville to less than 18 in in the western sections of the Valley. Periods of maximum rainfall usually occur during May and June and September and October. For the latter period, rainstorms of high intensity caused by tropical hurricanes are common.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Houston, Tex., June, 1951, as a contribution of the Soil and Water Division. It is a joint contribution of the Texas Agricultural Experiment Station (Substation No. 15) and the Division of Irrigation, Soil Conservation Service, U.S. Department of Agriculture.

The authors: MORRIS E. BLOODWORTH, agricultural engineer, Texas Agricultural Experiment Station; P. EARL ROSS, irrigation engineer, Soil Conservation Service (Research), U.S. Department of Agriculture, Weslaco, Tex.).

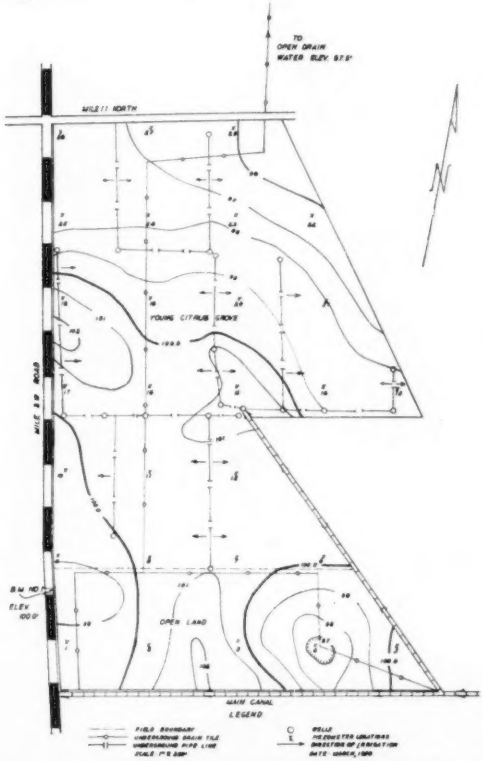

Fig. 1 Map of the J. F. Martin farm drainage project near Weslaco, Texas

The Valley includes three counties with a total area of 1,955,840 acres. Approximately 650,000 acres of the total acreage are being devoted to irrigated agriculture. The topography may be described as practically level to undulating, with elevations ranging from near sea level at the coast to 75 ft in the midvalley. Elevations varying from 200 to 300 ft with slopes up to 2 and 3 per cent are found in the western part. With the exception of the Arroyo Colorado which originates in the western end of the Valley and continues east to the Gulf of Mexico, major natural drainage channels do not exist. The Rio Grande River affords limited drainage to areas immediately adjacent to the river. The problems of overflow have been relieved to a great extent during the past 10 years by the construction of a system of floodways that contains the overflow waters from the river. The floodways also serve as outlets for many of the open-surface drain ditches and in turn empty into the Gulf of Mexico.

Soils on the slopes are usually sandy loams and sandy clay loams, whereas those occupying the areas along the Rio Grande River and level lands in the eastern section are clay loams and heavy clays. All of the soils are highly calcareous. The character of the soil profile in some areas is such that frequently there is a very restricted flow of water laterally. Soils found in other localities have good internal drainage characteristics but lie over slowly to very slowly permeable clay layers which retard the downward movement of free water through the soil. With the continued application of excessive quantities of irrigation water, a "perched" water table is often set up, and the ground water table continues to rise toward the surface. As the free water approaches the ground surface, moisture evaporates and leaves a deposit of salts in the topsoil. These saline salts accumulate and present a dangerous hazard to soil productivity unless remedial measures are applied.

The Lower Rio Grande Valley is a relatively new irrigated area as compared to some of the others in this country. The first irrigation project had its beginning in 1876 near Brownsville when plantings of sugar cane and rice were made on heavy clay soils. Those crops were short lived because of poor irrigation practices that resulted in high water tables and increased soil salinity. The more important irrigation and land developments have been made during the last 30 years. Today approximately 650,000 acres are being irrigated with water pumped from the Rio Grande River and distributed by 27 irrigation districts to farm lands planted to field crops, vegetables and citrus trees.

The river water is considered to be of good quality for irrigation purposes even though approximately one ton of salts are deposited in the soil with the application of each acre-foot of water. Salt concentrations vary from 500 to 1250 ppm (total soluble solids), depending to a great extent upon the season of the year. The sodium percentage averages approximately 43 per cent but is not considered too dangerous due to the highly calcareous soils. The boron content ranges between the limits of 0.10 to 0.32 ppm. This quantity (10)* is not excessive for citrus or other crops that are sensitive to boron.

The problem of maintaining and improving soil productivity by preventing the harmful accumulation of salts in the fertile valley soils is of utmost importance. This will require continued stress on the importance of good irrigation management and cultural practices on land that remains in good production, and reclamation practices for lands where produc-

*Numbers in parentheses refer to the appended references.

tion is lowered or has been lost as a result of high water tables and salinity. The future prosperity of this area, as well as many others in the state and nation, will depend to a great extent upon whether or not the irrigated lands can be kept in production economically.

A cooperative program of irrigation and drainage research was initiated in the summer of 1948 by the Texas Agricultural Experiment Station and the U.S. Soil Conservation Service (Research) division of irrigation. This program was developed on a cooperative basis in order that a pooling of funds and personnel could be utilized more effectively for an attack on local problems of common interest in irrigated agriculture. The objectives outlined for the research program in drainage were divided into two phases. The first phase was to determine the nature and magnitude of the problem, if one existed, and the second phase was to determine the most effective and economical remedial measures that could be applied to reduce or eliminate the problem.

It has been definitely established that an over-all drainage problem exists in the Lower Rio Grande Valley. Through field studies and observations made during the last three years, the present problem can be attributed to several factors as follows:

1 Lack of irrigation land preparation for a uniform distribution of irrigation water.

2 Lack of knowledge regarding the character of the soils and their capabilities.

3 Excessive applications of irrigation water to soils with low subsoil permeabilities.

4 Lack of natural subsurface drainage through the Valley in general.

5 Lack of an adequately coordinated agronomic and irrigation management program.

6 Inadequate surface drainage system to permit fast removal of seepage and flood waters.

The problems existing today have been brought about largely by the unwise use of irrigation water by the individual farm owner or operator. This has been due to a great extent, perhaps, to his lack of understanding or knowledge of the importance of a close relationship between good irrigation management and agronomic practices. Both affect the successful drainage and reclamation of agricultural lands. These points would indicate, therefore, that our coordinated efforts for applying remedial measures to the present drainage problems require more than the mechanical phase of installing tile drains. They will necessitate a study and understanding of the plant-soil-water relationships for each problem area.

Individual Farm Drainage. Due to the heterogeneous soils which range from heavy clays to sands with subsoils of very low permeabilities in many cases, it is impossible to recommend a general treatment or certain method of drainage that will apply to all problem areas. Each area of land or individual farm must be worked separately because the subsoils and underground strata differ as to type and depth in each locality.

A cooperative project for the drainage and reclamation of agricultural lands was initiated in the spring of 1950 on a 60-acre tract of land. Fifty acres were in citrus trees that were two years of age, and the remaining 10 acres were farmed in cotton and other field crops. A topographic map is shown in Fig. 1.

The initial survey of this farm was made by the Soil Conservation Service (Operations) at the request of the owner. The landowner was very distressed at the presence of a high water table in most areas of his grove, but salt spots had not appeared except in certain places below and following contour 98. He felt that tile was needed immediately and stated that he wanted to install a drainage system. Following a preliminary survey, it was decided that a main line be installed, its effectiveness checked and from the data design adequate laterals to the main line. Since this drainage problem appeared to be typical of many citrus groves and fields in the Lower Rio Grande Valley, the work was undertaken with the farmer and Soil Conservation Service (Operations) on an investigational basis to determine the problem and remedial measures needed.

The first recommendation was that the entire area be planted to Hubam clover for the improvement of soil structure and internal drainage, and to assist in utilizing a large amount of excessive soil water that had been applied through irrigation. The cover crop, after maturity, was to be rolled down with a stalk cutter or mowed to form a mulch on the soil surface. The mulch cover would lower soil temperatures and prevent excessive evaporation resulting from high summertime temperatures that are common to the area. Soil temperatures on unmulched land one inch below the soil surface were recorded as high as 156 F during the month of July, 1950.

The citrus trees were spaced 25 x 30 ft. They were young, with undeveloped root systems and required small quantities of water at this age. With the rough topography and lack of proper land preparation, it was physically impossible to control the application and distribution of water; consequently excessive amounts of water were applied at each irrigation. All canals were concrete lined, and water was delivered to different points on the land by underground concrete pipe. These factors eliminated the seepage hazard common to open ditches.

By digging a number of 4-in-diameter observation walls, it was found that the average depth to the water table was 4.2 ft in the 50-acre grove and less than 3 ft in certain areas below contour 98.

A soil profile survey (3) was made following a grid pattern in order that the barrier areas, if present, could be delineated. The survey indicated that heavy clay was present at depths ranging from 5 to 6 ft below contour 98. The high areas above contours 100 and 101, as shown on the map in Fig. 1, appeared to be free of excessive quantities of salt in the topsoil and the subsoil indicated good permeability to a depth of 12 ft.

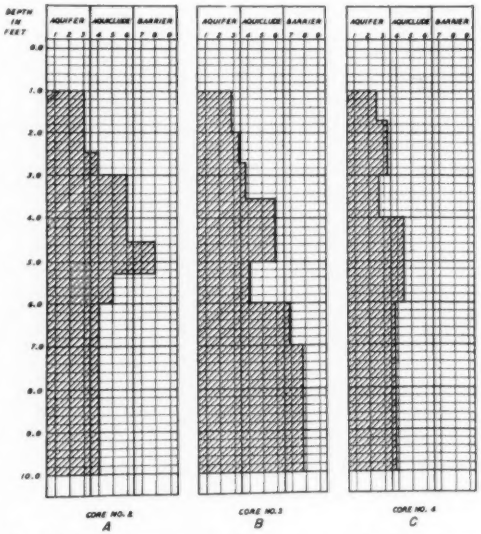

Fig. 2 Soil profile permeagraphs. Core No. 2—75 ft west of piezometer No. 16 (center of field). Core No. 3—75 ft north of piezometer No. 28 (corner of field). Core No. 4—200 ft west of piezometer No. 16 (center of field)

INDEX TO PERMEABILITY

1 =	12.0	to	90.0	cc per sq cm per hr
2 =	5.0	to	12.0	"
3 =	0.5	to	5.0	"
4 =	0.1	to	0.5	"
5 =	0.05	to	0.1	"
6 =	0.01	to	0.05	"
7 =	0.003	to	0.01	"
8 =	0.0005	to	0.003	"
9 =	0.00001	to	0.0005	"

The main tile drain was installed as shown on the map in Fig. 1. The soil profile survey and laboratory permeability studies were used to determine the depth at which the tile should be placed in order to keep it in permeable material as much as possible. Concrete pipe of 12-in diameter and 3 ft in length, was used for tile joints. The tile line was graded 0.1 ft per 100 ft and the effluent was discharged by gravity in a drainage ditch located north of the Martin farm. The depth of the draintile varied from 5 to 11 ft. Due to shallow drain ditches at many locations where tile lines are installed, it is often necessary to use a sump with an automatic electric pump for lifting drainage water to surface drain ditch levels.

To study the problem further and to compile data for designing the lateral lines into the tile, undisturbed soil cores 4-in diameter were taken in the problem areas to a depth of 10 ft with a soil-sampling machine (5, 6). This added refinement to the soil survey was necessary in order that permeabilities for the soil profiles could be determined. The soil cores were cut in 1-ft sections and permeability determinations were made by techniques (1, 12) previously developed at this station. Three of the resulting permeagraphs are shown in Fig. 2. With present methods now available for field use, it is possible to run permeability on undisturbed soil cores ranging up to 4 ft in length. By inserting piezometer tubes along one side of the 4-ft soil sample at different intervals and attaching them to glass manometer tubes, it is possible to locate accurately the presence of clay lense and barrier sections in the soil profile.

Piezometers (2, 4, 8, 9) were installed 400 ft apart in a grid system over the entire area, in order that the water-table fluctuations could be observed. It was later found that more piezometers were needed at somewhat closer intervals. Additional units were driven and batteries of four piezometers were set at different depths and installed at different locations. Although a regional water table is present in many areas through the Valley, deep piezometers did not indicate that it was affecting the shallow ground water table at this location. Observation wells were dug on adjacent farms that were at lower elevations than the Martin farmland. Water-table levels on the adjacent areas were found to be well below those of the problem areas under study. This indicated that the source of trouble was localized and probably resulting from excessive application of irrigation water.

Straddle piezometers were driven at 12½, 25, 50, 100, 200, 300, and 400-ft intervals perpendicular to the main tile line to check the gradient or drawdown of the water table as influenced by the subsurface drainage system. Although the tile has not been installed a sufficient length of time to draw any definite conclusions as to its over-all effectiveness, the drawdown curves do look promising. There seems to be a rather close correlation between the subsoil permeabilities as determined from the undisturbed soil samples and the surrounding area influenced by the tile drain. Additional studies will be necessary in this area, however, before attempting to use a tile-spacing formula (3, 7, 11) similar to that which has been developed in other areas.

Tile-effluent measurements and salt-concentration checks have been taken at intervals betweens irrigation and rainfall cycles. The flow averaged approximately 30 gpm during 1950, with a minimum of 10 gpm in February and a maximum of 55 gpm in August following heavy applications of irrigation water. Total soluble salts of the effluent have varied from 9600 to 18,400 ppm, with an average boron content of 5.52 ppm.

Studies conducted during 1950 rather definitely indicate that the main source of trouble is the continued application of excessive amounts of irrigation water. Physical control for obtaining a uniform application of water is not possible due to the absence of a properly designed irrigation system. Since there is no possible way of changing the present irrigation system because of the permanency of the citrus trees, sprinkler irrigation with an agronomic program of permanent grass and legume sod culture is recommended. The quantity and rate of water application can be controlled on the steeper slopes if this method of irrigation is used. Additional salinity trouble has been anticipated on the east side below contour 99. As a result, the next lateral tile line has been recommended to be installed starting near Mile 3 Road on the west side and following approximately contour 99. Soil permeability along this location has been found comparable to that shown for Core 4, Fig. 2(C); however, soil profile logs taken below this location show soil permeability comparable to Core 3, Fig. 2(B). This points out the necessity for permeability determinations before tile installations are made. This would minimize the possibility of a saline area developing with a high water table below contour 99.

The preceding discussion on the Martin drainage project has been presented as an illustration of the approach, procedures and partial results obtained so far in drainage studies conducted by cooperative research in the Lower Rio Grande Valley. It indicates the importance and necessity of a thorough investigation of the problem at hand before the design and installation of remedial measures. Many miles of draintile have been installed by rule-of-thumb methods or surface appearance with little thought given to the soil-profile characteristics as they affect the movement of water. Some of these installations have been successful, but many have been costly failures. It is believed that a large portion of the farmlands in the Valley can be prevented from reaching the point of requiring reclamation practices if proper irrigation management and good agronomic programs are instituted and maintained. Some of the local lands have reached a critical stage, however, and will require subsurface drainage before reclamation can be started and carried to completion. Leaching or flushing of saline salts cannot be successfully accomplished unless an outlet for the leachate is made available.

It should be stated again that problems involving irrigation and drainage are so closely related that it is practically impossible to separate them for analytical purposes. This fact should emphasize the necessity of obtaining and maintaining a favorable balance in plant-soil-water relationships in the irrigated areas. If irrigated agriculture is to be permanent in the Lower Rio Grande Valley or any other part of the nation, this balanced relationship will have to be maintained.

The following suggestions are made as possible preventive and relief measures for localized drainage and salinity problems:

1 Proper land preparation for a uniform distribution of irrigation water.

2 Install and maintain a properly designed irrigation system based on plant needs, topography and soil characteristics.

3 Plan and maintain a good agronomic program for the maintenance and improvement of soil productivity.

4 Installation and maintenance of adequate surface-drainage systems for the removal of surplus surface and subsurface drainage waters.

5 Where the reclamation or improvement of soil productivity cannot be accomplished by use of good irrigation management and agronomic practices, subsurface tile drains should be installed as a relief measure under the supervision of trained technicians.

SUMMARY

The unwise use of irrigation water and lack of an adequately coordinated agronomic program have contributed to a serious drainage problem in many irrigated sections of the Lower Rio Grande Valley of Texas. This situation is causing an increasing demand for information on the reclamation and drainage of saline soils.

A cooperative program of research in irrigation and drainage has been developed and initiated in the Lower Rio Grande Valley. There were two major objectives outlined for the drainage program. The first objective was to determine the nature and magnitude of the problem, and the second one was to determine the most effective and economical methods whereby the problem could be reduced or eliminated.

Factors that have contributed to the present problem have been presented. An illustration of the approach, procedures and research results obtained to date were given for an individual farm drainage study that is being conducted on a cooperative basis. The problem was defined through field and laboratory studies, and remedial measures were recommended to the owner. *(Continued on page 673)*

Trade Catalogs an Integral Part of Engineers' Library

By Nancy Iran Phillips

A TECHNICAL library in which books, trade catalogs, periodicals, patents, and reports are organized under one classification system has recently been completed for the advanced engineering department at the McCormick Works of International Harvester Co. Planned for efficient and useful presentation of information to engineers, designers, draftsmen, and purchasing agents, the entire collection is classified by the Dewey Decimal System.

The largest portion of the collection is composed of trade catalogs which present manufacturers' specifications for a multitude of machine components. It was found necessary to expand the 621.8 machine design and power transmission division of the decimal classification for a more orderly arrangement of the diversified material. The 621.2 hydraulic engineering division was also revised to provide for special hydraulic components related to the farm implement design carried on by members of the department.

These expansions together with the recent 15th Edition, Standard D.C. expansion of classes 660-679 provided a means for arranging the trade catalogs in proximity with books, patents, and other periodicals on related subjects.

In this special library which caters to designers of farm implements, the agronomy and other agriculture sections of the 14th Edition of D.C. were well suited to the plan. Patents, advertising literature, and textbooks on the subject of farm wagons, for instance, may all be found within a small area of the library.

The actual expansion and cataloging of the trade publications was undertaken only after much research on the subject. Engineering libraries large and small throughout the United States and England were studied, and many companies generously offered their assistance in explaining their own systems.

During a year of research it was discovered that few libraries have ever tried to classify trade catalogs by more than a company name, alphabetical arrangement.

It was felt that with this library, greater progress would be made in designing if engineers were led to a variety of related material, rather than continuing reference to one particular company merely because of familiarity.

A dictionary catalog with terse abstracts was one means of providing this expanding view for the engineers. Subject headings for such a catalog were not available in any of the standard references. This is where engineers themselves had an opportunity to share in the planning of the library. Before any classification or cataloging had commenced, each member of the engineering staff was asked to list possible subject headings for each of 20 publications, the collection having been divided equally among the department members. They were asked to list on the back of an index card the headings under which they might look to again find a particular catalog.

On the front of the card was listed the name of the company, its address, the title of the catalog, the number of the catalog, or its date of publication, and the fact that it was copyrighted or not. A key number was also given the publication and placed on the card. The catalogs were arranged in alphabetical order by company, and then given numbers based on the alphabet, and the order of the catalog within the letter range. This enabled the engineers to find the catalogs during the classification.

The author: MISS NANCY IRAN PHILLIPS was until recently librarian in Mr. Raney's department and directed the library development described in this article.

EDITOR'S NOTE: This article was made available for publication in AGRICULTURAL ENGINEERING through the courtesy of Russell R. Raney, chief engineer, advanced engineering dept., McCormick Works, International Harvester Co., 2919 South Western Ave., Chicago 8, Ill. It will doubtless prove of interest to other engineers faced with the problem of maintaining a file of trade catalogs in their libraries. Mr. Raney has kindly consented to supply, on request, copies of the classification and subject heading lists used in cataloging the library's trade catalogs.

Since this article was written, there has been a change in the organization of the library described. There has been set up in Mr. Raney's department a committee to assume complete responsibility for the operation of the library. This committee consists of the engineering staff photographer, three engineering staff members, a senior engineer as chairman of the committee, and a secretary to carry on the business and correspondence of the library.

The secretary and photographer are permanent members of the committee. The photographer is charged with the responsibility of filing in the library all still pictures and a resume of each motion picture film which he has stored in a fireproof vault. The three engineering staff members do the classifying of the materials and carry on the daily functions of the library. They are replaced every three months while the chairman serves for a period of 6 months. This rotation is to give all department members a thorough understanding of the library, the material in it, and how it operates. To date this system has worked satisfactorily.

The library is combined with a conference room, both of which are shown in the accompanying illustrations. The library has its own bulletin board which posts notices of additions of important new material. The most recent editions of periodicals are displayed in a magazine rack, while back issues are stored on the lower levels of book shelves.

Views of the library and conference room of the advanced engineering department at the McCormick Works, International Harvester Co.

It was then possible, in most instances, to make the classification on the basis of the information on the card, rather than requiring constant reference to the catalogs themselves. In this way the catalogs were placed in the proper divisions on the basis of where the engineers expected to find them.

The subject headings, too, had the advantage of being the very word groups which the engineers would use in looking for the publications. However, it was realized that typing cards for each of their many phrases for one publication would be an impossible task. So the dictionary catalog was based on 200 decimal class titles into which the catalogs had been placed. The many varied subject headings all lead the users to the actual card filed in one of the 200 classes.

It was decided early in the organizational thinking that Library of Congress cards should be used wherever possible. It was found that these were useful for textbooks only. They are used, with the suggested D.C. classifications, and the L.C. subject headings. These have been correlated with the other subject headings.

Patents indexed are mostly concerned with farm implements, and are easily and logically placed in the 630 division of Dewey. The catalog cards for patents are typed on blue cards. Each of them uses the title assigned by the U.S. Patent office as its main subject heading. Following this information, and the Dewey number in the upper left-hand corner, is the patent number, the date issued, the name of the inventor, and the company for which he is assigner. A quotation from the patent itself illustrating one feature of the machine is also included. The subject headings include the patent name, the patent number, the inventor's name, and the company, as well as the name of the Dewey Decimal class in which it is placed.

INFORMATION ON CARDS FOR TRADE CATALOGS

The catalog cards for the trade catalogs are typed on salmon cards, and contain the following information. The decimal class number, the name of the company — typed in red in lieu of bold face type. If the catalog concerns the product of a division of a larger company, it is the name of the parent organization which is typed in red. Below the company name is the title of the catalog, the name of the publisher, i.e., the company selling the product. Here the fact that a division of the company produces the product is made apparent. The address is also listed, and the name of any representative or distributor. The number of the catalog and the date issued or received by the department is recorded, as well as the fact that the publication is copyrighted and contains engineering data, tables, etc. Listed below are the subject headings, including one for the main heading typed in red on each card. (This is to avoid neglecting it in revision work.) Again the parent organization and the division are used as two subject heading possibilities. Other headings deal with the subject matter itself. There is no attempt to use the title of the catalog as a heading.

Reports are handled in much the same way as patents. These cards are buff colored. Book cards are white, as are the L.C. cards which are used for most of them.

Because of the great variety of bindings used for trade catalogs, it was necessary to use pamphlet boxes for shelving them. However, another measure was taken to provide better organization of material for engineers. Where it was possible to bind the catalog in a fiberboard binder, this was done, but in so doing catalogs of one company or several companies dealing with the same subject matter were bound together, so the engineer has with him all of the trade catalogs on one subject at one time.

Sometimes, of course, this was not possible. Several of the catalogs are bound volumes not adaptable to further binding. The reader knows, however, that he does not have all of the information because the name of the companies represented in each binder is recorded on the book card of each binder. These book cards serve this purpose, as well as that of informing each member of the department of the exact location of the binder. When the book is in use, the name of the engineer using it is recorded on the card so that it may be referred to by consulting with him.

Members of the staff are not asked to return books to the shelves. This is taken care of by the librarian.

Drainage of Irrigated Lands in Lower Rio Grande Valley

(Continued from page 671)

Recommended preventive and relief measures for localized drainage and salinity problems were listed. These measures emphasized the necessity of obtaining and maintaining a favorable balance in plant-soil-water relationships in irrigated agriculture.

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Utilization of Human Resources

I WOULD say that the engineering mind in business means application of the same orderly procedures, the same honesty of purpose, the same respect for truth and facts that are the very foundation of the scientific and the engineering world. Or, as the Bible puts it, "Ye shall know the truth and the truth will make you free."

Then what is the answer? It seems to me that more effective utilization of our human resources deserves at least as much attention as the utilization of our material resources has been receiving during the past fifty years.

We spend time and money in our colleges training our youngsters in various professions, but we do little or nothing in preparing them to use this newly acquired knowledge effectively to their own and to society's best interest. We leave this almost entirely to chance. Would it not be wonderful if, for instance, every young engineer graduating from a school were trained not only to evaluate the assets he has acquired there in terms of their application to his potential jobs, but also in terms of their use in his being a more effective member of society and a better citizen of his country?

It seems to me that much too often we are wastefully ineffective because we ignore the simple and the obvious.—Col. John Slezak in *Midwest Engineer* for October, 1951.

Threshability of Ladino Clover as Affected by Moisture

By D. R. Long
ASSOCIATE MEMBER ASAE

IN THRESHING experimental plots of forage, it is important that all samples of a test be equally threshed. Not only is equal threshing necessary but harvesting and processing techniques should be the same for all samples within a test. Equal threshing is not possible unless the moisture content of all samples in the test remains constant throughout the threshing process. Since the relative humidity of the air affects the per cent of seed obtained from threshing, measures should be taken to insure the same moisture content of all samples within a test. Tests on the moisture equilibrium, and the effect of moisture on the threshability of Ladino clover were conducted by the agricultural engineering department of the Oregon Agricultural Experiment Station.

Threshability may be defined as the ease with which seed is separated from the florets. As will be noted from Fig. 2 there is an inverse relationship between the moisture content of the sample being threshed and the per cent of seed obtained. A sample of high moisture content results in low threshability whereas the reverse is true for one of low moisture content.

To determine the proper conditioning procedure for Ladino clover, a moisture equilibrium curve was required. These moisture equilibrium studies were patterned after basic research work accomplished by C. Ivan Branton, fiber flax division, Bureau of Plant Industry, Soils, and Agricultural Engineering, USDA, at Corvallis, Ore., and Frank J. Zink, agricultural engineering department, Kansas State College, Manhattan. Mr. Branton's (unpublished) studies on moisture equilibrium of fiber flax were conducted at 80 F and 140 F. Mr. Zink's* work on U.S. No. 1 red clover was conducted at 80 F and 84 F.

In determining the moisture equilibrium of Ladino clover, samples were prepared and placed in small aluminum baskets. Each basket was assigned to an airtight moisture can. The samples, in their respective baskets, were placed along with the airtight moisture cans in an experimental drier-conditioner and the conditioner set to maintain a dry-bulb temperature of 100 F. The operator, by varying the intake of outside air, and the wet-bulb temperature, maintained an atmosphere of desired relative humidity within the conditioner.

At the end of a 6-hr conditioning period, samples and moisture cans were removed from the conditioner. The sample in the basket was placed quickly in the moisture can, sealed, and weighed with a 1000-gr analytical balance. Samples were then subjected to a temperature of 205 F for 40 hr, in a Scientific Laboratory's heat oven. Samples were again weighed. This procedure was followed in bringing samples to their equilibrium moisture content at relative humidities of 24.5, 40, 50, 60, 70, and 80 per cent. Five samples each were conditioned at these relative humidities and an average moisture content determined for each of the above humidities. A moisture equilibrium curve was plotted from the data obtained from these tests and the correct conditioning procedures for samples to be threshed were determined from this moisture equilibrium curve (Fig. 1).

Material to be threshed which consisted of approximate yard square samples of Ladino clover were conditioned for 6 hr at 9.5, 20, 29, 39.5, 56, 68, 75, and 80.5 per cent relative humidity with a dry-bulb temperature of 100 F. While the samples were being conditioned, some of the air from the conditioning chamber of the drier was by-passed into a 29-gal can. Small strips of rubber were cemented to the under side of the lid and when in place effected an airtight container. After conditioning, samples were quickly placed in the airtight can which held the samples under the same condition as existed in the drier. Threshing immediately followed conditioning. Precautionary measures were taken to thresh each sample equally and thus minimize threshing error.

Yard square samples of Ladino clover, replicated three times, were conditioned to moisture contents (dry basis) of 18, 16, 14, 12, 10, 9, 8, and 6 per cent. Each sample was threshed three times and the threshings designated by run 1, 2, and 3. The seed obtained from three runs was assumed to be 100 per cent of the total threshable seed in the clover heads.

The seed obtained from the threshing of conditioned samples was first cleaned with a Bates aspirator to remove chaff and foreign matter, and then recleaned with a Dakota blower to separate fine chaff and lightweight material from the seed. Clean seed was then weighed with an analytical balance. Complete data were recorded and analyzed statistically by Dr. J. C. R. Li, biometrician for the Oregon station. From the data obtained on these tests, a threshability curve was determined as shown in Fig. 2.

DISCUSSION

All samples in the test were *(Continued on page 676)*

This paper, prepared expressly for AGRICULTURAL ENGINEERING, is based on a thesis by the author and is a contribution of the agricultural engineering department, Oregon State College. It is published with the approval of the director as Technical Paper No. 704, Oregon Agricultural Experiment Station.

The author: D. R. LONG, assistant professor of agricultural engineering, Oregon State College, Corvallis.

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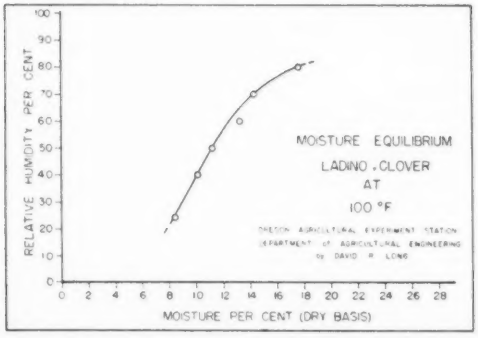

Fig. 1 In order that samples of Ladino clover could be threshed at a desired per cent moisture content, a moisture equilibrium curve was needed

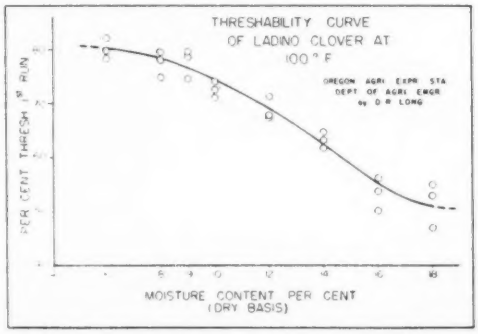

Fig. 2 The above curve shows that as the moisture increased from 10 to 18 per cent, the threshability decreased, but as the moisture decreased from 9 to 6 per cent, the threshability was not significantly affected

Simplifying Poultry Ventilation with Mathematics

By Myron G. Cropsey
MEMBER ASAE

IN THE Northwest, winters are mild with very high relative humidities. It is common during a foggy period to have nearly 100 per cent relative humidity for a week at at a time. During such periods there is considerable wet litter, and it is very difficult during average winter weather to maintain dry litter. Usually relative humidity averages over 90 per cent for December, January, and February.

Ventilation has been tried in the past and has not been successful either due to insufficient insulation or improper ventilation. Several other methods have been tried, such as heating floors either by hot water or hot air, but these have not been widely accepted due to the first cost, and many times to operating costs.

This paper presents a mathematical analysis of the ventilation problem showing that with sufficient insulation it is theoretically possible to secure dry litter by ventilation even in the Northwest. Practically this was proved in an experiment conducted during the winter of 1950-51 at Oregon State College.

It can be assumed that in the Northwest the most difficult atmospheric condition is 40 F and 100 per cent relative humidity. The problem is to secure the lowest relative humidity by the optimum conditions of ventilation. If one can calculate the relative humidity by the solution of a formula without reference to a set of tables or charts, and then differentiate this formula with respect to the number of air changes per hour, and equate the differentiated formula to zero, one can secure the conditions of either maximum or minimum relative humidity. The problem is, first, to obtain a formula for the relative humidity, and, second, to differentiate this formula with respect to the number of air changes per hour. Then equate the formula to zero and solve for the conditions of minimum relative humidity. If this relative humidity is less than an accepted maximum, then dry litter should result. It generally has been stated that a relative humidity less than 80 per cent is necessary. This formula, of course, does not take into account condensation below the dew point. The formula for relative humidity is

$$RH = e_t/e_s \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [1]$$

where e_t and e_s are, respectively, vapor pressure at the dry-bulb temperature and vapor pressure at saturation of the dry-bulb temperature.

First, solve for vapor pressure at the dry-bulb temperature. This can be secured from the formula for specific humidity in terms of vapor pressure $pv = wR[t + 460]$, if $R = 0.753$ for dry air, if pressure is in inches of mercury, and $R = 1.21$ for water vapor, if pressure is in inches of mercury.

Specific humidity is the weight of water vapor divided by weight of dry air of a mixture, and the formula for specific humidity is

$$W = \frac{e_t}{1.21\ (t + 460)} \div \frac{B - e_t}{0.753\ (t + 460)} =$$

$$0.622\ e_t/(B - e_t) \text{ (pounds)}$$

where B = atmospheric pressure. (All pressures in the above formula are in inches of mercury.) The partial pressure due to water vapor is then

$$e_t = BW/(0.622 + W) \text{ (inches of mercury)}$$

or
$$e_t = \frac{BW\ (0.492)}{(0.622 + W)} \text{ (pounds per square inch)} \quad . \quad [2]$$

The next step is to secure the specific humidity or the weight of water vapor in a mixture divided by the weight of dry air. For a poultry house this would be W = weight of water in mixture of outside air added per hour + weight of water vapor added by poultry per hour ÷ weight of dry air added to the poultry house per hour.

If N = equal number of air changes per hour, V = volume in cubic feet, D_w = weight of water vapor per cubic foot of mixture at 40 F and 100 per cent relative humidity, and D_a = weight of dry air per cubic foot at 40 F per hr, then $W = (NVD_w +$ water added per hour by poultry$) \div NVD_a$.

Water added per hour by poultry equals $17\,C/1043$*, which includes both water from respiration and droppings. The factor 1043 is the latent heat of evaporation at body temperature of the chickens, and C is the number of chickens.

$$\text{Then } W = \frac{NVD_w + (17\,C/1043)}{NVD_a}$$

Substituting the above equation in equation [2],

$$e_t = \frac{B\ (0.492)\ \dfrac{NVD_w + (17\,C/1043)}{NVD_a}}{0.622 + \dfrac{NVD_w + (17\,C/1043)}{NVD_a}}$$

$$e_t = B\ (0.492) \cdot \frac{NVD_w + (17\,C/1043)}{0.622\,NVD_a + NVD_w + (17\,C/1043)} \quad . \quad [3]$$

(The factor $17\,C/1043$ in the denominator will not affect the final answer to any extent if omitted.)

For air at 40 F and 100 per cent relative humidity in equation [3], we have

$$e_t = B\ (0.492)\ (0.0082 + C\ (0.326)/NV)$$

and for $B = 30$ in

$$e_t = 14.75\ (0.0082 + C\ (0.326)/NV) \text{ (lbs per sq in)} \quad . \quad [4]$$

We can now solve for vapor pressure at saturation. Let $e_s = K_1 + K_2\,\Delta t + K_3\,(\Delta t)^2 + \ldots$. The first three terms

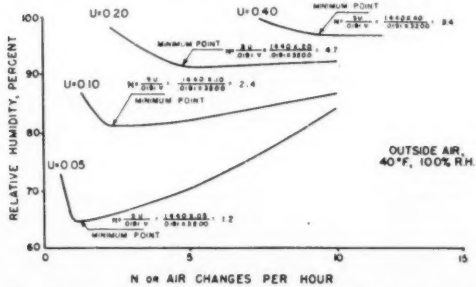

Fig. 1 Relative humidity versus air changes per hour for a poultry house, for 125 birds, 20x20 ft by 8 ft high, with various thicknesses of insulation

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

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*Sammet, L. L. and Barre, H. J.: Air Flow in Poultry House Ventilation—A Theoretical Analysis. AGRICULTURAL ENGINEERING, vol. 30:332 (July, 1949).

would be sufficiently accurate. For a Δt above 40 F, this would be

$$e_s = 0.1217 + (0.0048)\,\Delta t + 0.000095\,(\Delta t)^2$$

The total heat produced by a hen is about 60 Btu per hr, and 17 Btu is to be used for vaporizing water which leaves 43 Btu as sensible heat*.

The heat lost by ventilation from the exchange of air is $\Delta t\,NV\,(0.241)/12.69$. This does not take into account specific heat of water vapor which is small at 40 F.

The heat lost by conduction through the wall is $\Delta t SU$, where U = coefficient of heat transfer (weighted average) and S = square feet of surface.

$$\Delta t = \frac{43C}{NV\,(0.24/12.69) + SU} = \frac{43C}{NV\,(0.0191) + SU}$$

$$e_s = 0.1217 + \frac{43C\,(0.0048)}{SU + NV\,(0.0191)} + \frac{0.000095\,(43C)^2}{SU + NV\,(0.0191)^2} \quad . \quad . \quad . \quad . \quad [5]$$

Substituting in equation [1] inside relative humidity, when outside it is 100 per cent at 40 F, is then

$$\frac{e_i}{e_s} = \frac{14.75\,(0.0082 + C\,(0.326)/NV)}{0.1217 + \dfrac{43C\,(0.0048)}{(SU + NV\,0.0191)} + \dfrac{0.000095\,(43C)^2}{(SU + NV\,0.0191)^2}} \quad [6]$$

This formula is accurate to about ± 1 per cent for about 15 F temperature differential.

One now has a formula for inside relative humidity with incoming air at 100 per cent relative humidity and 40 F. This formula can also be made for any other set of conditions necessary. If the number of chickens is known, also air changes per hour, cubic volume, square feet of surface, and coefficient of heat transfer, the relative humidity can be found.

If the constant 14.75 and 0.0082 in the numerator are multiplied, the product is 0.1209, which may be considered for practical purposes the same as 0.1217 the first term in the denominator. Differentiating relative humidity with respect to N (the number of air changes per hour), one of the roots is $(SU + NV\,0.0191)$. By equating this to zero to determine the point of minimum relative humidity, one gets the following formula which represents the number of air changes to secure the minimum relative humidity:

$$N = -SU/V\,(0.0191) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [7]$$

This formula is very simple and gives the number of air changes per hour to secure the lowest relative humidity. While it gives the point of ventilation which will give the lowest relative humidity for any one set of conditions, this resulting relative humidity may not be low enough, and it is necessary to use formula [6] to determine the relative humidity. By the proper use of these two formulas, the proper conditions for dry litter can be secured (Fig. 1). Practically an over-all coefficient of heat transfer of at least 0.10 is necessary to secure dry litter by the use of insulation and ventilation in western Oregon. Many times this would be rather expensive and the proper degree of ventilation can be used as an assisting factor to another method when less insulation is used. Experiments conducted during the winter of 1950-51 resulted in dry litter with sufficient insulation and the proper amount of ventilation as calculated by this formula. A check pen of the same size required five changes of litter.

These two formulas can be adapted to other temperatures and humidities by changing some of the constants. At very low temperatures, 10 F and below, the air becomes saturated with only small quantities of water; consequently, a temperature rise of 10 to 15 F will not produce relative humidities below 100 per cent by ventilation alone.

These formulas are not applicable to dairy cows because the rate of heat given off by them changes rapidly with the changes in temperature. It is assumed in these formulas that the rate of heat production does not change with temperatures, which for practical purposes is true for chickens.

Due to other factors in the differentiated formula for relative humidity, the answer given by formula [7] is slightly on the side of less ventilation. Usually this amount is small.

Threshability of Ladino Clover

(Continued from page 674)

handled equally to insure comparable results. In threshing, each sample was handled the same. The operation of the threshing machine was the same for each sample.

It was shown in the test results that a decrease in moisture content from 18 to 10 per cent, increased the amount of seed obtained significantly. And from the analysis by Li, it may be concluded that as the moisture increased from 10 to 18 per cent, the threshability decreased, but as the moisture decreased from 9 to 6 per cent, the threshability was not significantly affected. This indicates the necessity for equal conditioning of all samples to be threshed. Results obtained from threshing experimental tests of Ladino clover are of little value in comparing one with another statistically, unless all samples have been threshed at the same moisture content.

The test results also show that the seed obtained from the first threshing of a high-moisture-content sample will be low and the subsequent runs will be high. The reverse is true for the low-moisture samples in which the seed obtained from the first threshing will be high and the subsequent runs will be low. The data also show that the amount of seed obtained from the first of three threshings of a sample at 6 per cent moisture content (dry basis) is greater than the seed obtained from all three threshings of a sample at 18 per cent moisture content (dry basis). This is important, not only from an experimental viewpoint but also as a reminder to commercial operators that Ladino clover must be threshed when the forage is at its lowest field moisture content. Ladino clover must be threshed when at a low moisture content to obtain a maximum amount of seed.

CONCLUSIONS

1 It is important that methods and techniques for handling samples of forage plots be handled the same for all tests.

2 Threshability tests on Ladino clover show conclusively the effect of moisture on the per cent of seed threshed.

3 More seed can be threshed from a low-moisture-content sample than one of high moisture content.

4 In statistically comparing the threshing results of experimental forage plot samples the moisture content must be the same for all samples within a test.

5 Equal threshing techniques and methods must be conducted on comparable samples between various branch experiment stations. In statistically comparing the yield from the same crop between branch stations, it is necessary that the conditioning of these samples be equal.

Understanding Our System

IT IS only through meeting face to face and exchanging views with others that we can really understand how goods are produced and distributed, how funds are secured for building and carrying on industry, how adequate profits benefit everyone connected with the business which creates them, how the whole economic system of this great free country works. Most of all, it is to the advantage of everyone — not just a few — that we continue under a system which *made* this country — where *more* people have *more* things than any others in the world. Let's all get busy improving the system we have. We do not *destroy* a house simply because the roof leaks. L. J. Fletcher, vice-president, Caterpillar Tractor Co., before the California Farm Equipment Dealers Assn.

A Study of Absolute Humidity Conditions in the Gulf Coast Rice Area

By Harold A. Kramer
MEMBER ASAE

THE absolute humidity of the atmosphere is of vital interest to those engaged in crop drying as there is, for each crop, an atmospheric condition above which it becomes impractical to remove excess moisture by forced circulation of atmospheric air alone. The addition of supplemental heat may then become desirable.

These conditions are now being studied in extensive basic research conducted by the U.S. Department of Agriculture on "rate of drying." This work, when completed, will provide a mathematical formula for calculating the rate of moisture loss from a crop when it is exposed to any given atmospheric conditions. The basic theory of this work has been published in AGRICULTURAL ENGINEERING (1)* and perhaps in other literature.

The formula will be particularly useful in the bulk or bin drying of rice. Assume a steel bin, with perforated floor, containing a known volume of rice of known uniform moisture content. Using drying air of a given quantity, temperature, and water content, it will be possible by use of the formula to predict with accuracy the time required to dry any portion of the rice to a desired moisture. If time is the critical factor, and quantity of air is relatively fixed by blower capacity, then the required air temperature and/or humidity can be calculated.

Experience and preliminary research in developing the drying-rate formula have shown that in the Gulf Coast Area atmospheric air alone is not a satisfactory drying medium for rice. Supplemental heat is required to furnish an efficient and dependable drying condition. The amount of supplemental heat required depends largely upon the water content of the atmosphere at the time drying is performed. The purpose of this study is to supply such information.

During the 19-year period, 1910 to 1928, inclusive, daily wet and dry-bulb temperatures were recorded, as a part of routine weather observations, at the Louisiana Rice Experiment Station, Crowley, La.(2). These temperatures were taken at approximately 6 a.m., noon, and at 6 p.m. Occasional observations were missed, but the omissions appear to be largely randomized and their effect on the over-all record should be negligible. During the period studied there were 2547 separate observations made in the forenoon, 1891 at noon, and 5130 in the afternoon, or a grand total of 9568.

Because of the effect of different dry-bulb temperatures, relative humidity may be misleading, especially when comparing the water content of the atmosphere at several geographic locations. For the purposes of this study all wet and dry-bulb readings were reduced to absolute humidity (grains of water vapor per pound of dry air) (3, 4).

The following statement is taken from AGRICULTURAL ENGINEERING (5): "One of the basic concepts which has been contributed by statistical science is that which points out the meaninglessness of a simple mean in the absence of the frequency distribution from which it is derived. It need not be emphasized that, for agricultural purposes, simple monthly means of precipitation and temperature are of no great value. But if the mean for a given period is supplemented by some information about the frequency of occurrence of specific ranges of temperature and/or precipitation over a given more or less homogeneous area, some useful information is immediately forthcoming. From the frequency distributions the probability of occurrence of a specified precipitation amount and/or temperature can be computed. By the introduction of the time element, duration frequencies can be established and used in a similar way. For example, the probability of a 15-day drought occurring during the month of June over any specified region can be determined from the duration-frequency distribution of periods with negligible amounts of rain. This, then, is approaching the point at which a farmer's weather risk can be computed for a specified crop."

The foregoing quotation applies equally well to rice dry-

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Houston, Tex., June, 1951, as a contribution of the Farm Structures Division.

The author: HAROLD A. KRAMER, formerly agricultural engineer, agricultural engineering divisions, U.S. Department of Agriculture.

*Numbers in parentheses refer to the appended references.

TABLE I. Monthly Mean Absolute Humidities and Deviations from the Mean Observed at Crowley, Louisiana, 1910-1928, Inclusive

Month	Time of Observation	Absolute Humidity in Grains Water Vapor per Pound Dry Air	One Standard Deviation in Grains Water Vapor per Pound Dry Air
January	a.m.	50.75	27.23
	noon	50.82	28.18
	p.m.	56.28	24.56
February	a.m.	51.69	23.00
	noon	57.44	23.90
	p.m.	60.09	24.79
March	a.m.	61.13	26.66
	noon	62.70	24.99
	p.m.	66.51	26.02
April	a.m.	77.26	24.70
	noon	75.12	25.84
	p.m.	79.92	25.52
May	a.m.	96.76	21.93
	noon	89.55	21.95
	p.m.	94.64	22.80
June	a.m.	120.31	16.22
	noon	116.72	19.76
	p.m.	120.67	16.11
July	a.m.	133.80	14.00
	noon	133.15	19.27
	p.m.	130.92	15.19
August	a.m.	135.52	13.86
	noon	136.24	17.79
	p.m.	133.23	16.96
September	a.m.	116.96	24.83
	noon	115.44	26.82
	p.m.	117.34	24.51
October	a.m.	90.94	31.31
	noon	94.27	30.98
	p.m.	87.42	29.94
November	a.m.	61.07	27.76
	noon	58.26	27.09
	p.m.	64.20	25.87
December	a.m.	51.28	25.15
	noon	55.36	27.03
	p.m.	57.15	27.26

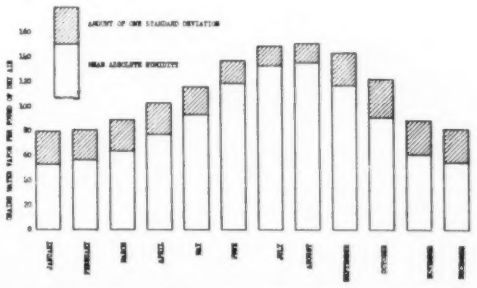

Fig. 1 This graph shows the mean absolute humidity for each month and the corresponding value for the mean plus one standard deviation

ing, in which statistical methods provide a means by which one can compute from weather records the mathematical odds that the atmosphere will contain a specified amount of water during a given period. Readers not familiar with the methods used in making these calculations are referred to several texts on the subject (6, 7).

In this study the humidity data have been separately calculated for each month of the year. This was done to simplify presentation of the data as preliminary checks showed little difference between results for a month and for periods of shorter duration, during the same month. Separate calculations were made for observations made in the forenoon, at noon, and in the afternoon.

Table 1 shows the average water content of the atmosphere and also the plus or minus variation from the average for the respective daily periods given during each month. The variations are given in terms of one standard deviation. In a normal curve one standard deviation each side of the mean includes approximately 68 per cent of the total observations. Consequently there are about two chances in three that the atmospheric water content will not exceed the mean plus or minus one standard deviation, at any one date. For example, the probabilities are about 6.25 to 1 that on any future day in June, the water content of the air at Crowley, La., will not exceed 136 grains of water vapor per pound of dry air. This is calculated from a mean of 119 plus one standard deviation of 17 grains. Two standard deviations include about 95 per cent of the total observations, which means that the chances are about 40 to 1 that, for the same date and location, the absolute humidity will not exceed 153 grains (mean of 119 plus two standard deviations of 17 grains each). Thus we can compute to any desired risk the mathematical odds that a favorable absolute humidity for drying will exist during a specified month.

Fig. 1 shows the mean absolute humidity for each month and also shows the corresponding value for the mean plus one standard deviation. A maximum mean of 136 grains occurs during August and a minimum mean of 51 grains occurs during January. The maximum deviation from the mean occurs during October and the minimum during July.

Table 2 is reproduced in its entirety from a previous publication (8). It provides data on average monthly dry-bulb temperatures, evaporation, precipitation, and wind velocity, which are a valuable supplement to the absolute humidity data in Table 1.

The purpose of this study was to provide information on the average absolute humidity of the atmosphere, and the probability of a given variation from the average occuring at any desired date. Much practical use can be made of such data, both in developing design requirements for future drying facilities and improvements in the use of future and existing drying equipment.

The data given apply particularly to the Crowley, La. area, but are typical of conditions adjacent to the Gulf as far west as Beaumont, Tex. It is hoped that similar data will be compiled by others for other rice-growing areas such as in Arkansas and California.

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8 Jenkins, J. Mitchell: Weather Observations at the Rice Experiment Station, Crowley, La. For the 33-year period 1910 to 1942, inclusive, Louisiana State University Bulletin No. 376, March, 1944 (23 pps)

Sequel to Increased Agricultural Production

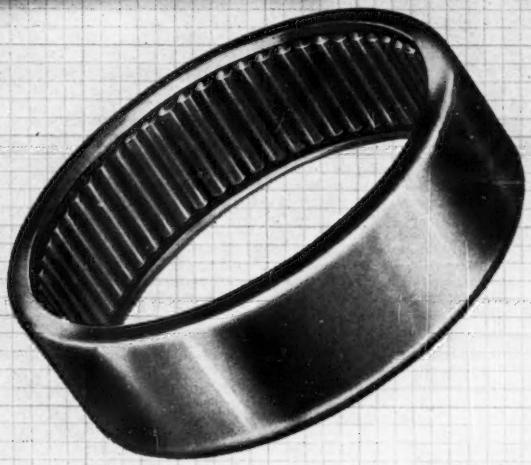
AN INCREASE in agricultural production naturally leads to industrial development. But it is a step-by-step process — little industries that eventually lead to big industries. As the people learn to produce more food and as surplus food production frees labor from the field, raw materials for small industries become available, along with labor to process them.

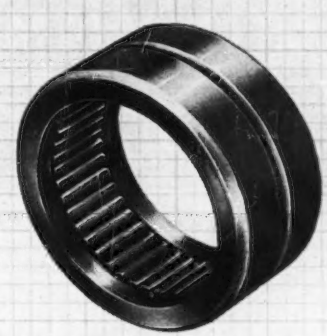
This is a gap that needs to be closed in most of the rural countries. I referred to the millions of cattle I saw in Africa, without packing plants to process and preserve the meat, the hides and by-products. The people there, and in comparable areas, don't need large, expensive factories. They need a little local packing plant, a little local shoe factory, a little local textile mill. They don't need vast amounts of capital from outside. They need to *know how* to use their own capital, their own raw materials, their own resources, to produce for their own vast internal markets. An American technician in Bolivia reports that Bolivians have asked him how they might profitably and safely invest a million dollars in local enterprises. There is a job — an almost limitless job — for American industrial engineering in the other regions of the earth.— Dr. Henry G. Bennett in *Journal of Engineering Education* for November, 1951.

TABLE II. Thirty-three Year Average Weather Readings for the Period 1910 to 1942, Incl. at the Rice Experiment Station, Crowley, Louisiana

	Air Temperatures, Degrees F.					No. of	Precipitation		Evaporation		
				Monthly Extreme				No. of		Mean Temp.	
Month	Mean	Max.	Min.	Max.	Min.	days with ice	Inches	days with rain	Inches	of water in tank*	Wind Velocity Miles per day
January	54	63	44	77	26	5	5.23	11	2.176	57	4.1
February	56	66	46	78#	29#	3#	4.07	10	2.574	60	4.5
March	61	70	50	82	34	1	3.97	9	3.654	65	4.8
April	68	78	57	86	40	0.03	3.87	8	4.710	72	4.5
May	75	84	64	91	52	0	4.93	8	5.751	80	3.5
June	81	89	72	95	64	0	4.92	11	6.087	85	2.6
July	82	90	74	96	69	0	6.17	13	5.654	88	2.0
August	82	91	73	96	67	0	6.32	13	5.649	88	1.9
September	78	88	68	94	56	0	4.26	10	5.024	84	2.1
October	70	81	58	90	40	0.27	3.39	8	4.310	75	2.4
November	60	71	48	84	30	2	4.45	8	2.913	64	3.0
December	54	64	44	78	28	5	5.79	12	2.359	59	3.6
ANNUAL							57.38		50.891		

* 23-year average # 31-year average





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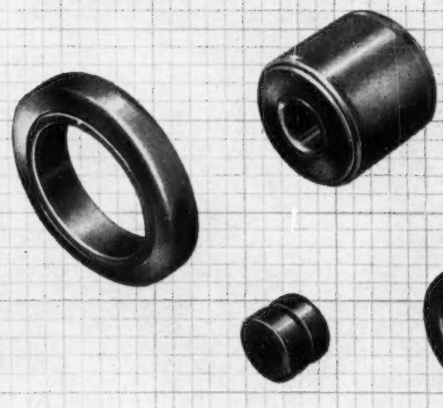

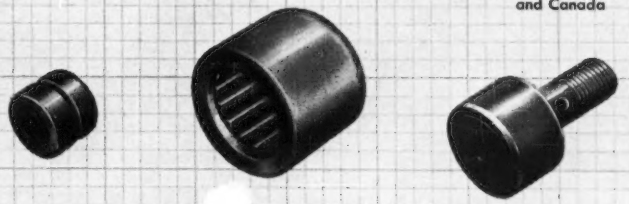

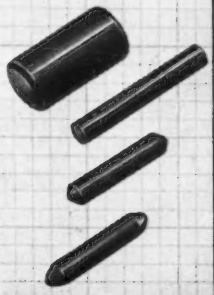

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RESEARCH NOTES

ASAE members and friends are invited to supply, for publication under this heading, brief news notes and reports on research activities of special agricultural engineering interest, whether of federal or state agencies or of manufacturing and service organizations. This may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Mich.

USDA Notes on Mechanization, Tractor Rims, Elevator Storage, Apple Bruising, Crop Drying

Research Aids Farm Mechanization. The mechanization of agriculture, aided by agricultural engineering research, has been a major factor in giving this nation the food and fiber it has required to take its place of leadership in the world, in the opinion of the director of agricultural engineering research in the U.S. Department of Agriculture. The director, Arthur W. Turner, addressed the 50th anniversary seminar of the Bureau of Plant Industry, Soils, and Agricultural Engineering at the Agricultural Research Center, October 24, on the contribution of agricultural engineering research in the Department during the past half century.

"One only needs to compare the farms of today with the farms of 1900 to realize the role mechanization has played," he said. "A farmer today produces more in one hour than he did in two 50 years ago. Today American farmers are using horsepower instead of horses to produce the record-breaking crops. There are nearly 4 million tractors on the farms today, and almost 90 per cent of all farms are receiving electric power. These advances help explain why only 16 per cent of our population now living on the farms, can meet the food and clothing demands of the rest of us."

In reporting research achievements through the years, Turner described the role engineers had played as consultants to the USDA's Commodity Credit Corporation in areas where commercial storage facilities were inadequate; the plans and specifications they developed for low-cost farm housing; the development of a seed cotton drier now used in more than 5,000 gins, which has added 20 million dollars annually to the income of cotton growers; the development of a lint flue cleaner now used in some 1,500 gins, which has added 5 million dollars each year to growers' incomes; and tests of tractor tires and wheels at the U.S. Tillage Machinery Laboratory, Auburn, Ala., suggesting design improvements that may bring a saving of 10 per cent annually in fuel costs for tractor operations.

Future need for agricultural engineering research will be greater than ever, he predicted. There are yet many crops to be mechanized, and improvements to the mechanization of others further along. The many uses that can be made of electricity on the farm have been barely tapped. There is an especial need for additional engineering research concerned with reducing time and labor spent around farm buildings. Production must be as efficient in the industry of agriculture as in any other industry, if America is to maintain its strong position in the world, Turner said.

• • •

Wider Tractor Rims Do Not Increase Pulling Power. The standard 14-in-width tractor rim provides just as much pulling power for tractors operating in dry sand as do wider rims, according to research findings of the USDA at the Tillage Machinery Laboratory, Auburn, Ala. Tests sponsored by a committee of the tire industry and using tractor tires with button-type and bar-type tread on 12, 14, 16, and 18-in rims showed no gain in drawbar pull or traction efficiency with the wider rims. Effect of rim width on tires operating in types of soil other than sand are currently being determined in tests at the Laboratory.

The engineers carrying out the research concluded that for the most drawbar pull and efficiency when operating in dry sand, the inflation pressure of the tires should be as low as possible without causing tire damage.

For the best combination of efficiency and pulling power in dry sand, the engineers recommend operating the tractor with tire pressure at 12 lb and at speeds and loads that result in very little slippage or less than 20 per cent slippage as measured by the engineers.

• • •

Elevator Needs in the South. Some of the major problems attending the South's need of elevator storage for its increasing grain production are answered in a recent University of Georgia bulletin, authored by research engineers of the University and the U.S. Department of Agriculture.

After studying storage facilities in five southeastern states and comparing them with the more complete facilities of Illinois and Indiana, the engineers concluded that anyone going into the elevator business also should plan for a sideline such as feed milling or selling of farm supplies to augment his income and at the same time use labor more efficiently.

Structures of reinforced concrete are common, especially for elevators with a capacity greater than 75,000 bu. Steel is generally more economical for elevators of less capacity, the engineers say.

A southern elevator of 75,000 bu, constructed of reinforced concrete and with necessary equipment, should cost about $1.25 for each bushel of capacity. The cost per bushel will run less for larger capacity elevators and more for smaller ones.

Some modification of midwestern elevator design is necessary to make them adaptable to the South. The poor natural drying afforded by the warm and humid weather of the South would require the inclusion of an artificial drier in any modern southern elevator. Likewise, designs should include adequate truck loading and delivery facilities.

• • •

Engineers Reduce Apple Bruising. Apple bruising, which costs growers, packers, and distributors an estimated $10 million annually, can be greatly reduced with the use of improved equipment and by careful handling from orchard to market, in the opinion of research engineers of the U.S. Department of Agriculture.

In cooperation with Michigan State College, the research men subjected apples of different sizes and varieties to vertical drops ranging from 1 to 24 in on different types of surfaces, and applied different pressures to the fruit to determine the amount and size of resultant bruises. With this information, plus their observations of picking, hauling and packing operations, they are able to offer recommendations to improve the quality of marketed apples. Their suggestions are contained in Michigan Agricultural Experiment Station Special Bulletin 374, "How to Reduce Apple Bruising."

The engineers found that use of proper equipment plus careful handling, without loss of time or efficiency, could result in an apple reaching the market with an average of only five small (5/16-in diameter) bruises. The current average is 20 bruises, each averaging more than ⅜ in in diameter.

Dumping apples from a picker bucket into a field crate caused more damage than any other orchard operation. The canvas bottoms of picker buckets are too often released at the top edge of the field crate, allowing the fruit to fall against the bottom of the crate or against other apples, resulting in an average of 366 bruises for every 300 apples. However, placing the bucket near the bottom of the crate before loosening the canvas bottom reduced the number of bruises to 57. The size of each bruise was reduced about one-third.

• • •

Crop Drying Has Bright Future. Mechanical drying of most harvested grains and forage crops will eventually be a routine farm job, in the opinion of W. V. Hukill, USDA engineer. He told guests attending the fiftieth anniversary seminar of the Bureau of Plant Industry, Soils, and Agricultural Engineering, at Beltsville, Md., October 25, that there has been rapid and widespread acceptance of drying, both by seed companies and grain elevators, and by farmers.

Crop drying has had this rapid acceptance not because of developments of drying equipment and methods alone, but because of a combination of changing conditions that permit the economical use of such new methods, Hukill said. The availability of electricity for power and the increased number of gasoline power plants on farms have been major reasons. Rapid harvesting methods with combine and corn picker do not allow time for natural drying that older, slower harvesting processes did. Also, he said, in days of high production with fewer farm workers, it is imperative that we use methods of harvesting and safely storing farm crops that save labor and time.

There are more than 10,000 forage driers in use on farms today, because farmers have found this method of handling forage crops gives them more and higher quality forage than other methods. Hay can be harvested when it is at its nutritive best and dried in the barn without running the risk of weather damage during field curing. Mechanical drying also reduces the danger of fire from spontaneous combustion.

Drying small grain offers similar advantages, Hukill states. Farmers can beat bad weather losses by harvesting early and drying the grain artificially to safe storage moisture content. Early harvest reduces losses from lodging and shattering, and the harvest season can be shortened by operating the combine in morning and evening when the grain is wet from dew.

Corn drying permits harvesting in good weather which reduces field losses, even though the kernel moisture content is still high. Or, early harvested corn can be shelled at harvest time and then dried. The farmer with a drier also has the opportunity of growing later-maturing, higher-yielding hybrid varieties, relying on his drier to reduce the high moisture content of the corn after harvest.

• • •

The Hon. Knox T. Hutchinson, Assistant Secretary of Agriculture, in addressing the Washington (D.C.) Section of ASAE recently, called upon all agricultural engineers to bolster the defense program. Our primary job, he said, is to make the people of this nation realize that food and fiber production are the basis for any success we may achieve in our defense efforts.

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NEWS SECTION

Pacific Coast Section to Meet January 31

A ONE-DAY meeting of the Pacific Coast Section of ASAE at Davis, Calif., January 31, is one of a series of four successive agricultural engineering gatherings scheduled to be held there over the 7-day period from January 30 to February 5.

The Third Annual California Farm Structures Conference on January 30 will open the series. February 1 and 2 are the dates for the 21st Annual Farm Machinery Conference. The 23rd Annual Rural Electric Conference is scheduled for February 4 and 5.

Hunt Hall on the University of California campus at Davis has been reserved for the daytime sessions of the Section. Registration is to begin there at 9:00 a.m.

R. Earl Storie, presiding, is to call the first session to order at 9:30. First on the program is to be a panel discussion on "The Why and How of Surface Soil Tillage." It will be covered from the soil physics standpoint by Paul R. Day, assistant soil physicist; from the soil moisture standpoint by Lloyd D. Doneen, associate irrigation economist, and from the engineering standpoint by J. P. Fairbank, regional director, agricultural extension service, all of the University of California.

In a similar approach to "The Why and How of Land Clearing for Range Improvement," the why is to be covered by Lee Burchun, range technician, California Division of Forestry; the how, by Rudolph F. Grah, extension specialist in forestry; and reseeding by V. P. Osterli and James L. Myler, University of California.

Thor W. Christiansen, chairman of the Section, will preside at its annual business meeting following the noon luncheon. For the afternoon session, the papers scheduled include "A Wet Bulb Thermocouple," by S. Milton Henderson; "The Hydraulics of Pipe Lines with Multiple Small Outlets," by Clarence N. Johnston; "Engineering Problems in the Design of Specialty Equipment," by Coby Lorenzen; and "Removal of Metals from Feed Materials," by Frederic C. Jacob and John B. Dobie. The speakers are all from the University of California.

Features of the dinner program in the evening will include an illustrated talk on "Japan and Her People" by Harry B. Walker. Ralph R. Parks will be master of ceremonies for the dinner and entertainment.

Programs for the Section meeting and for the related conferences may be obtained from the division of agricultural engineering, University of California, Davis.

Iowa-Illinois Section in Joint Meeting

APPROXIMATELY 120 agricultural engineers attended the joint meeting at Peoria, October 26, when the Caterpillar Tractor Co. and the USDA Northern Regional Research Laboratory were joint hosts to the Iowa-Illinois Section and local sections of the ASME, SAE, ACS, and ASM. All arrangements and details of the meeting were under the direction of Frank P. Hanson, agricultural engineer, Caterpillar Tractor Co.

The program started at 1 p.m. with several optional tours through the new Caterpillar engine factory or through the Northern Regional Research Laboratory running concurrently with a theater program including a motion picture, "Power for Protection," showing application of equipment for gully control, pond building, terracing, etc. Included on this program was an illustrated lecture, "Economies of Construction Equipment on Farms" by M. O. Crowe, sales development division, Caterpillar Tractor Co. Fred R. Jolly, manager of the Company's community relations department, gave a brief description of the food-handling system and facilities which enable Caterpillar to serve over 15,000 meals per day to its employees.

All of those present were guests of the Caterpillar Tractor Co. at dinner. The evening program started with a motion picture, "The Farmer Does the Job," which showed the many uses for track-type tractors in food production. With Leonard J. Fletcher, vice-president of Caterpillar Tractor Co. acting as moderator, the main paper of the evening was read by Thomas L. Apjohn, assistant director of refining, Petroleum Administration for Defense, Washington, D.C., on the subject, "Fuels for Civilian Use in Event of War." Mr. Apjohn's paper included an analysis of the current petroleum situation and in effect predicted that in event of war it is expected that, without severe bombing, there will be sufficient fuel available of good quality to meet the essential needs of the civilian economy. This address was followed by a panel of short papers, the first by C. G. A. Rosen, consulting engineer, administrative department, Caterpillar Tractor Co., on the subject: "Burning Petroleum Fuels in the Agricultural Internal-Combustion Engine in Time of War." E. J. Stirniman, consultant, agricultural sales, was scheduled to discuss "How Will War Fuels Influence Animal Power," but as he was unable to attend the meeting, Dick Sharp took his place. Dr. Richard Wiebe, head, motor fuels evaluation division, Northern Regional Research Laboratory, discussed "Emergency Fuels from Agricultural Residues," and Dr. R. T. Milner, director of the Northern Regional Research Laboratory discussed "The Role of Alcohol as an Emergency Fuel." This panel period was followed by questions from the floor pertaining to the general theme of "Fuels for Food Production in Event of War."

ASAE Meetings Calendar

December 17-19—WINTER MEETING, The Stevens, Chicago, Ill.

January 11—WASHINGTON (D.C.) SECTION, Room 6962, South Bldg., USDA, Washington.

January 29—MINNESOTA SECTION, University of Minnesota, University Farm, St. Paul

January 31—PACIFIC COAST SECTION, Hunt Hall, University of California, Davis, Calif.

February 4-6—SOUTHEAST SECTION, Atlanta Biltmore Hotel, Atlanta, Ga.

March 21—OHIO SECTION, Ives Hall, Ohio State University, Columbus

April 10 and 11—PENNSYLVANIA SECTION, Agricultural Engineering Bldg., Pennsylvania State College, State College

June 16-18—15TH ANNUAL MEETING, Hotel Muehlebach, Kansas City, Mo.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Michigan

Hutchinson Addresses Washington Section

THE Hon. Knox T. Hutchinson, Assistant Secretary of Agriculture, addressed the November 9 meeting of the Washington (D.C.) Section of ASAE.

Secretary Hutchinson's subject was "Functions of Machinery in Meeting Production Goals." He pointed out that agricultural engineering is a strong member of the production team in peace as well as for any emergency. Attention was called to the fact that this emergency is different from those in the past in that a high standard of living is being maintained along with our defense program. In spite of high taxes, the purchasing power of the average individual is higher than ever before.

Mr. Hutchinson indicated that our defense program aims to provide (1) a small armed force equipped on a year-to-year basis, (2) production potential ready to turn over at a moment's notice, and (3) continued high production of civilian goods.

Mechanization has made this possible. Over-all plans call for a return to near normal conditions in 1953.

Agriculture is actually a defense agency and is becoming more and more dependent on farm machinery, fertilizers, insecticides, and skilled labor. The farm labor problem becomes more acute because it is becoming more exacting. Industry has many sources of labor while the essential labor for agriculture must come from the farms.

The speaker pointed out that we gained about 20 million acres of cropland for feeding livestock by substituting tractor power for horse power. At the peak of our use of horses and mules we had 27 million horse and mule power. We now have 750 million horsepower available for use on farms. At present one person out of every eight is employed in agriculture. With our great advance in mechanization in the Mississippi Delta we can now produce a bale of cotton with 11 hours of labor, while under the one-mule system it required 146 hours of labor.

In closing, the speaker pointed out that with more and better machines, more fertilizers, better varieties, and advanced conservation farming practices, we will be able to maintain our high standard of living without slowing down or endangering our defense program.

J. H. Browne presided over the meeting in the absence of the Section chairman, B. C. Reynolds. A total of 50 members and visitors attended.

Dr. Waldo H. Kliever, director of research, Minneapolis-Honeywell Regulator Co., was announced as the scheduled speaker for the next Section meeting, December 14. His subject will be "Research on Instrumentation in Agriculture."

(News continued on page 684)

ANCHOR

Clamp-Type, Reusable Coupling
Positive Grip — Easily Applied

...for hydraulic hose, ideal for both emergency field-repair service and original equipment application

Yes, here's a hydraulic hose coupling you can count on. It has a powerful grip and can be used with one- or two-wire braid hose for medium or high pressures, or fabric hose. Impulses can't shake it loose — yet it's reusable again and again, is put on or taken off quickly.

Because Anchor clamp-type couplings stay on the job, outlast the hose, hydraulic systems stay dependable, perform the way they were designed to perform.

Dependability isn't the only feature of this Anchor coupling... just look at these advantages:

Neat installation — made possible by compact design of the Anchor clamp and the use of streamlined Anchor adapter unions and related fittings.

Easy to apply — no special tools needed to attach or detach — just two automotive-type wrenches. And, it's unnecessary to strip the cover off the hose.

Built to take it — clamping segments are specially designed to give the extra strength needed in hydraulic service, insert stem machined from high-grade steel rod stock, bolts are heat-treated and all parts are rust proof.

Saves time — you don't have to wait for repairs because you can make up your hose lengths as needed. Stocking problem minimized.

This clamp-type coupling is widely used on equipment subjected to rough going. For example, many earthmoving and oil-field equipment manufacturers standardize on Anchor to assure maximum dependability under the toughest possible conditions. This is the coupling for you, too — the coupling with the grip that stops complaints. Write today for catalog of sheets giving size tables and recommended working pressures.

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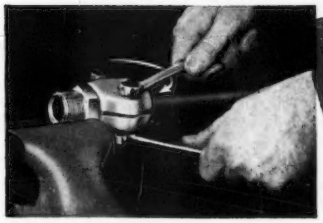

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I want to know more about your clamp-type coupling that is so dependable and easy to use. Please send me catalog sheets.

Name.....Position.....
Company.....
Company Address.....
City.....(.....) State.....

D-8

NEWS SECTION *(Continued from page 682)*

Blasingame Honored by Pennsylvania Section

A FEATURE of the meeting of the Pennsylvania Section of ASAE at Pittsburgh, October 18 and 19, was the presentation of a plaque commemorating the long and distinguished service of Ralph Upshaw Blasingame to the state.

First public announcement of the honor was made at the dinner held during the Section meeting. Mr. Blasingame is retiring as head of the agricultural engineering department at Pennsylvania State College on December 31 of this year.

The presentation was to have been a surprise to Mr. Blasingame. Unfortunately he was under a doctor's care at the time and unable to be present. In his absence the plaque which is to be hung at the College, was received by Charles G. Burress, retiring chairman of the Section, for further presentation ceremonies at a later date.

The committee responsible for securing the plaque and the wording thereon were C. A. McDade, L. S. Singley, A. S. Mowery, E. K. Bonner, Jr., and B. P. Hess (chairman). It is of etched bronze mounted on a walnut base, designed to be hung in the Agricultural Engineering Building at Pennsylvania State College to pay tribute to Mr. Blasingame's many years of service and to provide inspiration to students, teachers, and visitors.

The technical sessions of the meeting featured two round-table discussions and six papers. One round-table discussion on infrared lamp brooding and controls was led by J. E. Nicholas and J. S. Perry, both of Pennsylvania State College, and W. D. Hemker of Westinghouse Electric Corp. Another round-table discussion on recent developments in dairy stable ventilation was led by H. V. Walton of Pennsylvania State College and H. R. Wakefield of United Cooperatives.

Technical papers included "Trends in Dairy Barn Equipment" by W. Floyd Keepers, Barn Equipment Assn.; "Trends in Milk Sanitation" by W. S. Anderson, Pennsylvania Bureau of Milk Sanitation; "Experiences with Processing and Handling Forage Crops" by J. E. Bobb, Hershey Estates Farms; "New Developments in Farm Machinery" by A. W. Clyde, Pennsylvania State College; "Single-Phase Motors for Rural Service" by D. E. Armstrong, Westinghouse Electric Corp.; and "Making the Poorest of Land Highly Productive" by C. H. Snyder, Sunny Hill Farms.

Two afternoons were devoted to tours through the East Pittsburgh plant of Westinghouse Electric Corp. and the laboratories of Gulf Oil Corp.

The Section dinner was presided over by B. A. Knight, Pennsylvania Power Co. The address, "MacArthur's Philippine Neighbors," was delivered by Francis McQuillin, assistant to the president, West Penn Power Co.

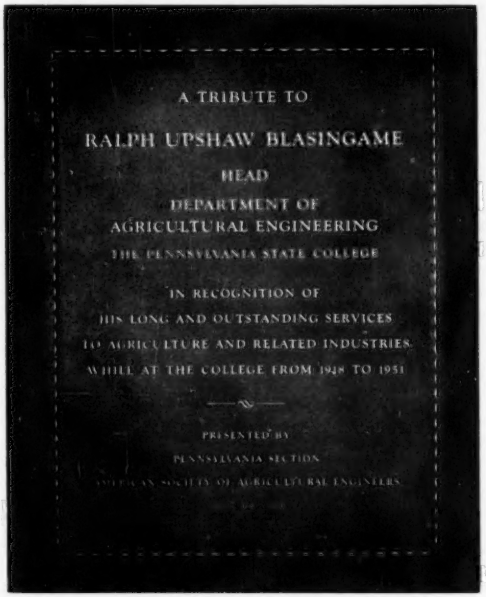
C. G. Burress, Section chairman, presided over the business meeting. A resolution was adopted to defray the expenses each year of two Penn State agricultural engineering students to the ASAE Pennsylvania Section meeting. New officers elected for 1951-52 are J. B. Stere, chairman; Albert M. Best, vice-chairman; and H. V. Walton, secretary-treasurer. J. A. McCurdy, G. K. McCutcheon, and O. C. Lange were elected to the Nominating Committee.

Dr. R. M. Salter New SCS Chief

DR. ROBERT M. SALTER, for almost ten years chief of the Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S. Department of Agriculture, has been named the new chief of the U.S. Soil Conservation Service, succeeding Dr. Hugh H. Bennett.

Dr. Salter is recognized as one of the nation's leading agronomists.

(Continued on page 686)



A plaque presented by the ASAE Pennsylvania Section honoring the many years of outstanding service of R. U. Blasingame as head of the agricultural engineering department of Pennsylvania State College

The group of members and guests of the ASAE Pennsylvania Section that visited the research laboratories of the Gulf Oil Corp. during the Section meeting in Pittsburgh, October 18 and 19. The laboratories are in the background

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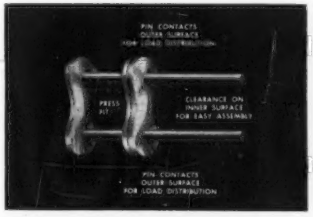

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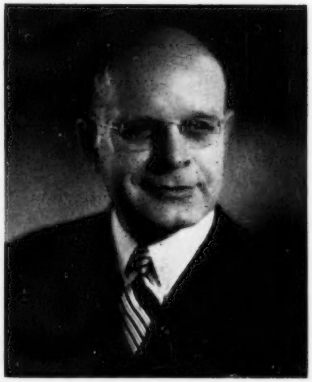
Agricultural Engineering Loses a Leader — Arthur W. Turner

THE profession of agricultural engineering lost a fine leader on November 17 with the passing of Arthur William Turner of the U.S. Department of Agriculture, at Prince Georges General Hospital in Cheverly, Md. Many members of the American Society of Agricultural Engineers also will feel that they have lost a great friend as well as professional leader, for he brought to his daily tasks a genuine interest in people that made others like him, and a capacity for leadership that inspired respect and devotion to the objectives of his profession.

Born in Worthington, Minn., on March 11, 1894, Mr. Turner had served for the past seven years as assistant chief and director of engineering research for the Bureau of Plant Industry, Soils, and Agricultural Engineering, with headquarters at Beltsville, Md. Under his administration were the Divisions of Farm Machinery, Farm Electrification, Farm Buildings and Rural Housing, and Mechanical Processing of Agricultural Commodities.



ARTHUR WILLIAM TURNER — 1894-1951

In his youth Arthur Turner lived for a number of years on a farm in Saskatchewan, Canada, near Moosejaw, which his father homesteaded. Later the family returned to Minnesota and Iowa where he received his education, attending Hamline University at St. Paul, Minn., and then Iowa State College. A graduate of Iowa State with a bachelor of science degree in Agricultural Engineering in 1917, he started his professional career as a tractor demonstration engineer with the Sandusky Tractor Co., Sandusky, Ohio. During World War I he was in service as an army YMCA secretary at Camp Dodge, Iowa.

At the end of the war, Mr. Turner went to Iowa State College to become extension agricultural engineer in soil erosion control. Later he served his alma mater for several years as associate professor of Agricultural Engineering. In 1927 he left Iowa State College to join what is now known as the consumer relations department of the International Harvester Co., Chicago, Ill.

While with International Mr. Turner prepared both agricultural and engineering sales data, organized and edited the IHC sales magazine, "International Power," planned sales training and promotion programs, and directed industrial trade show exhibits. With the beginning of World War II he was made educational adviser for the company and among other activities organized and directed IHC military training programs, including 13 Canadian Army mechanics schools, 5 Canadian Air Force ground power schools, and 3 U.S. Navy motor mechanics schools. In his work with International he was also very active in educational relations with colleges and universities and in rural youth organizations, becoming personally acquainted with the deans and directors of many of the land-grant colleges and with the state supervisors and staffs of vocational agriculture in all of the 48 states.

Mr. Turner became a member of the American Society of Agricultural Engineers on graduation from Iowa State College in 1917. He served as chairman of its Power and Machinery Division in 1940-41, and as President of the Society in 1943-44. Combining activities for his company and the Society, he made innumerable contacts with state college teaching, research and extension staffs, both agricultural and engineering, and with the farm and industrial press and radio stations, farm equipment manufacturing and sales organizations, electric manufacturing and utility companies, farm building and supply organizations, and federal agencies. During his years as President of the Society he traveled 31,000 miles by plane, train and bus, made numerous radio talks, appeared on various programs of the Society's Sections, and appeared before many regional and state extension and vocational agriculture conferences.

Plans for strengthening the engineering research work in the Department of Agriculture were initiated following World War II in discussions between the Agricultural Research Administration and a committee of the American Society of Agricultural Engineers. Mr. Turner was selected as the man best qualified to undertake this important assignment. In this position he organized numerous national and regional engineering research projects in cooperation with the state agricultural experiment stations. It was his constant objective to build a strong engineering research group in the Department, to take the leadership in solution of engineering problems affecting agriculture, and to give engineers equal status with other scientists in research teamwork for greater service to farmers and industry. In recent years at his invitation and suggestion, a number of industrial organizations have developed research committees for cooperative work with both the federal and state experimental agencies.

In addition to the American Society of Agricultural Engineers, Mr. Turner was a member of numerous other honorary and professional societies. He was a member of the American Association for the Advancement of Science and the American Society for Engineering Education, which he had served as chairman of the agricultural engineering division. He was also chairman of the National Joint Committee on Fertilizer Application in 1948, and a member of the Instrument Society of America and of the honorary engineering fraternity Tau Beta Pi. In 1945 he was made an Honorary American Farmer by the Future Farmers of America. He was a member of the Rotary Club of College Park, Md., the American Legion, and the First Methodist Church of Hyattsville, Md. He also had been recognized professionally by listings in "Who's Who in Engineering," "Men of Science," "Who's Who in the East," and other technical reference works.

During his engineering career Mr. Turner wrote many technical articles for both agricultural and engineering journals and made innumerable addresses in behalf of agricultural engineering research. He was the senior author of a vocational text recently published on machines for farm, ranch, and plantation.

The Turner home is at 3409 Rutgers St., University Hills, Md. Mrs. Turner is the former Elizabeth Parry of Carrol, Nebr. Their children include Mrs. John W. Holliday, Greenville, Ga.; Mrs. V. G. Stransky, Jr., College Park, Md., and Robert Parry Turner, a student at Wesley Junior College, Dover, Del. Mr. Turner is also survived by his mother, Mrs. Emma Seydel Turner, who lives near Mason City, Iowa. The funeral services were held at the First Methodist Church, Hyattsville, Md., on November 20, with interment in George Washington Cemetery, University, Md., just outside Washington, D.C.

Dr. Salter New SCS Chief

(Continued from page 684)

A native of Indiana and a graduate of Ohio State University, specializing in agricultural chemistry and soils, Dr. Salter was employed for over four years first as assist soils chemist and finally as head of the agronomy department of West Virginia University and its agricultural experiment station. He returned to Ohio in 1921 as professor of soils extension, was made chief agronomist of the Ohio Agricultural Experiment Station in 1925, and became chairman of the agronomy department of Ohio State University in 1929 and associate director of the agricultural experiment station in 1940. In October of 1940 he was appointed director of the North Carolina Agricultural Experiment Station. A year later he joined the USDA Bureau of Plant Industry, Soils, and Agricultural Engineering as head of the division of soils and fertilizers. He was appointed chief of the Bureau in April, 1942. Dr. Salter is succeeded as chief of BPISAE by Dr. Albert H. Moseman.

Dr. Salter has been a member of ASAE since 1943.

Minnesota Section Has Dinner Meeting

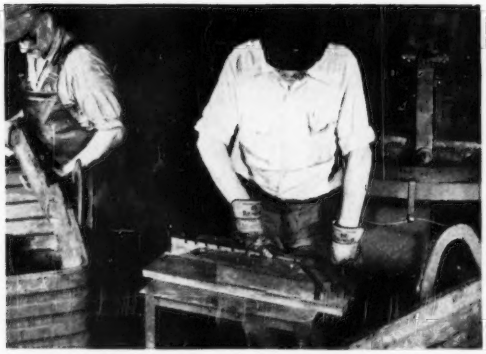
A DINNER, business session, and technical program combined drew more than 60 members and guests to the fall meeting of the Minnesota Section of ASAE, held at University Farm, St. Paul, the evening of October 30. *(Continued on page 688)*

A report to you about men and machines that help maintain International Harvester leadership

NEW McCormick® *Plow Chief Bottom* has a Replaceable Spearhead Point

The replaceable Spearhead point and matching share blade enable users to renew the performance of McCormick plows at lower cost and with less bother than sharpening old-fashioned shares. This is another example of IH design and development that benefits both dealer and farmer. Extra care in manufacture helps to guarantee good plowing.

1600-ton squeeze shapes Spearhead point from a white-hot bar of high-carbon steel. Here's a Spearhead point about to be dunked in cold water. This hardens the first four inches of its length for long wear . . . leaves the rest of it tough and strong. Gauging inspections and hardness tests safeguard the quality of Spearhead points.



Share blade can't vary 20,000th of an inch from perfection along its joint with the moldboard. This tight fit keeps dirt from building up and causing poor scouring. The inspector pictured gauging the share blade joint also gives the moldboard a similar check. Beveled edges on these joining parts of the Plow Chief bottom help to assure perfect fit.

32 different inspections make sure that shipping bundles picked at random from the warehouse will assemble into perfect-working plows. An inspector is shown checking the furrow wheel gather on a two-bottom McCormick plow set up in working position. Each Plow Chief bottom gets six different inspections in this quality-guarding spot check.

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TO ELIMINATE DANGER . . . of explosion or electric shock while drilling in wet or gassy mine conditions.

TO SPEED PRODUCTION In use figures prove that this flexible shaft application has increased production by more than 25%.

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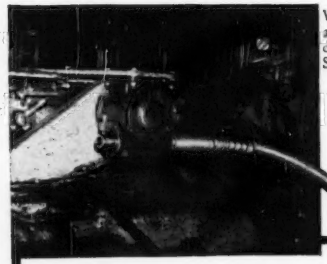

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NEWS SECTION *(Continued from page 686)*

"The Harvestore, Its Development and Use," was presented as an illustrated talk by E. O. Dueringer, agricultural research and engineering division, A. O. Smith Corp. Discussion was led by Thor W. Gullickson, dairy husbandry division, and W. F. Millier, agricultural engineering division, University of Minnesota, based on their experiences with the unit.

In the business session it was reported that the Section members by letter ballot had adopted a proposed revision of the by-laws.

C. K. Otis reported for A. J. Schwantes that a special committee had prepared a set of regulations for the guidance of the Section secretary-treasurer as to handling and filing of correspondence, membership rosters, programs, financial reports, etc. These were adopted on motion from the floor.

C. H. Christopherson, secretary-treasurer, reported on activities of the Section since its meeting in January. Two reported appointments by the Executive Committee were A. J. Schwantes, to the Speakers Bureau of the Minnesota Federation of Engineering Societies, and Albert N. Wold, to the Civilian Defense Committee of the same organization.

A motion was adopted calling for appointment of a committee to investigate the advisability of extending to the ASAE an invitation to hold its 1954 annual meeting in Minnesota.

Marvin J. Samuelson, chairman of the Section, announced that its next meeting would be held Tuesday evening, January 29.

Ohio Section Meeting Well Attended

AGRICULTURAL engineers and guests who gathered on the campus of the Ohio State University, October 27, for the fall meeting of their newly formed Ohio Section of ASAE, topped the 100 figure in attendance. This was more than double the number which formed the organization last May. Of this group, 95 made advance reservations and 94 attended the luncheon following the morning's program. H. N. Luebcke was program chairman and presided over the formal program.

A symposium on standardization of farm machinery component parts and hardware was presented by a panel of three engineers: B. C. Boulton, engineer in charge of production for New Idea, T. E. Martin, chief engineer for The Oliver Corp. plant at Springfield, and Ray Dobmeyer, project engineer with New Idea. They pointed out the need for standardization in the farm machinery industry and how the program was being approached.

Virgil Overholt outlined the responsibility of agricultural engineers in developing and promoting the practice of supplemental irrigation.

The Alcoa movie, "Right as Rain," which was judged winner of the 1951 ASAE Best Movie Awards Contest, was shown, featuring Virgil Overholt in the key role as a soil and water expert.

Following the luncheon, Larry Snyder, head track coach for the Ohio State University, gave a brief talk on where we stand in athletics today.

The next meeting of the Ohio Section will be held on March 21, at Ohio State University, during the 40th Annual Ohio Farm and Home Week.

Oklahoma Section Holds Annual Meeting

THE Oklahoma Section of the American Society of Agricultural Engineers met for a one-day program and business session November 16 at the Student Union Building, Oklahoma A. & M. College, Stillwater. Fifty men registered for the meeting, including representatives from state and national industrial organizations, power companies, Soil Conservation Service, Farmers Home Administration, and Oklahoma A. & M. College.

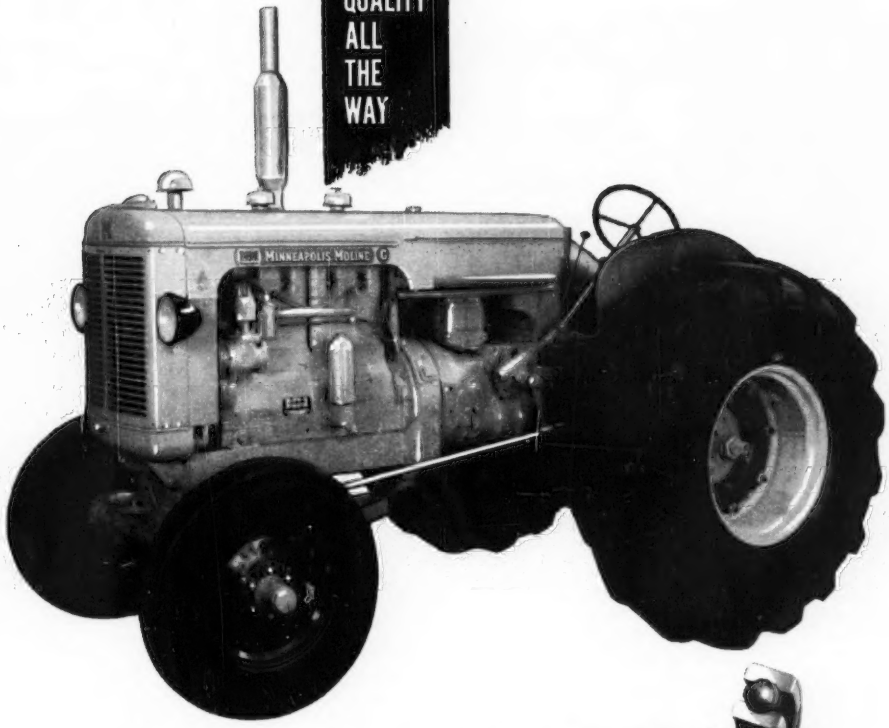
The morning program sessions described engineering and educational work being done statewide to obtain improved farm building construction on more Oklahoma farms. C. V. Phagan, Oklahoma A. & M. College; William Albright, Farmers Home Administration; W. M. Morgan, Oklahoma Lumbermen's Assn.; James McTaggart, Barney Stewart Lumber Co., and G. L. Nelson, Oklahoma A. & M. College, participated. Thomas E. Long, Portland Cement Assn., Chicago, presented data on effectiveness of different surface treatments in controlling moisture leakage through concrete masonry walls and outlined the important design and construction principles which, if followed, will help prevent moisture leakage through concrete masonry walls.

During the afternoon program, the group learned of new and improved machines being developed for special phases of Oklahoma agriculture. W. T. Wheeler, International Harvester Co.; Stewart Wood, The Boardman Co., and Maurice Cox, Soil Conservation Service, appeared on this part of the program. James Garton presented some new data on wear tests with pumps for agricultural field sprayers based on experimental work done by the agricultural engineering department at Oklahoma A. & M. College.

(News continued on page 690)

with MM AVERY

IT'S ALWAYS BEEN QUALITY ALL THE WAY



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BRONZE OBERDORFER SPRAYING PUMPS

New officers elected for the ensuing year are: Chairman, Maurice B. Cox, Soil Conservation Service; vice-chairman, W. T. Wheeler, International Harvester Co., and secretary-treasurer, G. L. Nelson, Oklahoma A. & M. College. Officers who had served the Section during the year then ending were: Chairman, Charles Bradford, Public Service Co. of Okla.; vice-chairman, Maurice B. Cox, Soil Conservation Service, and secretary-treasurer, G. L. Nelson, Oklahoma A. & M. College.

Society members and their guests dined together at a special noon luncheon. They were entertained by a newly released movie "Where the Floods Begin" prepared by the Public Service Company of Oklahoma to show how upstram detention reservoirs combined with other measures are helping to control runoff and flooding on the Washita River watershed in southwestern Oklahoma.

Dr. Brown New Chairman Engineering Section Tobacco Workers Conference

DR. O. A. BROWN, senior agricultural engineer, U.S. Department of Agriculture, stationed at Oxford, N. C., was named chairman of the Engineering Section of the Tobacco Workers Conference held recently at Clemson College, Clemson, S. C. J. N. Krueger, agricultural engineer, University of Kentucky, was named vice-chairman.

In a panel discussion at the Conference on the engineering problem of mechanizing the harvesting of tobacco, it was brought out that the problem can best be solved through cooperative efforts on a regional basis, and that this comprehends cooperation on the part of manufacturers, inventors, growers, and research workers of the USDA and various state agricultural experiment stations. Another point emphasized was that the harvesting problem is vitally affected by the curing method used, and any new development in curing will have an immediate effect on harvesting.

The program of the engineering section also included discussion and demonstration of new curing instruments and methods, demonstration of the clip-oil sucker control applicator, a field trip to inspect Turkish tobacco and use of the rotary hoe, and a tour of the new Agricultural Engineering Building at Clemson Agricultural College.

The next Tobacco Workers Conference will be held in Raleigh, N. C., during the summer of 1953.

Georgia Section Fall Meeting

A FALL meeting of the Georgia Section of ASAE at Athens on Saturday forenoon, November 3, featured talks as follows: "Welcome Address," by R. H. Driftmier; "Organization and Objectives of Branch Experiment Stations," by George H. King, associate director of experiment stations, college of agriculture, University of Georgia; "Agricultural Engineering Extension Work," by G. I. Johnson, extension agricultural engineer; "Looking Ahead in Georgia's Agriculture," by Kenneth Treanor, superintendent, Southeast Georgia Experiment Station; "Soil Conservation—A Forward Look," by C. W. Chapman, assistant state conservationist, SCS; and "Industry's Interest in Agriculture," by John T. Phillips, Jr., vice-president, Lilliston Implement Co.

In a short business meeting Roy J. McCraney was elected secretary to fill the unexpired term of James M. Stanley.

A motion carried authorized appointment of a program committee for a spring meeting and fishing trip.

The meeting adjourned at 12:30 p.m. to attend the homecoming football game between the Universities of Georgia and Alabama.

Harmond New Chairman of Pacific Northwest Section

JESSE E. HARMOND, senior agricultural engineer, divisions of agricultural engineering, U.S. Department of Agriculture, stationed at Oregon State College, was elected the new chairman of the Pacific Northwest Section of the American Society of Agricultural Engineers at its meeting held October 25-27 on the campus of the University of Idaho at Moscow. Other officers elected included four vice-chairmen, as follows: First vice-chairman, H. B. Howell, superintendent, J. J. Astor Branch, Oregon Agricultural Experiment Station; second vice-chairman, T. L. Coulthard, assistant professor of agricultural engineering, University of British Columbia; third vice-chairman, Walter W. Hinz, Anderson Miller & Poston Mfg. Co. The individual elected chairman of the agricultural engineering student group attending the same meeting automatically becomes fourth vice-chairman of the Section.

The new Section secretary and treasurer elected at this meeting is Fred N. Johnson, manager, irrigation dept., Armco Drainage and Metal Products, Inc., Portland, Ore.

At its business session, the Section voted to hold the 1952 meeting of the Section on the campus of Oregon State College at Corvallis.

(News continued on page 696)

BIG JOBS

...little jobs!

MASONITE TEMPERED PRESDWOOD does them all well!

Many of the recognized applications of Masonite Tempered Presdwood® have originated with the farmer himself.

This is the way it should be. For, as the farmer gets acquainted with the many advantages of this strong, tough, dense all-wood material, he will find new ways to put it to work for him.

Why does the farmer like it? It's the combination of Tempered Presdwood's smooth, dent-resistant surface, its ability to withstand any weather and continued wetness, the easy way it can be worked and applied with ordinary tools, its unending service at remarkably low cost per year.

We'd like to put a sample of tough, grainless Tempered Presdwood in your hands, entirely without obligation. Just mail the coupon—today!

Just a few of the jobs, big and little, Tempered Presdwood does best:

- Exterior siding on farm structures, new or old
- Milk house wall linings
- Hog house, permanent and portable
- Hog and poultry brooders
- Wagon linings
- Feeding boxes
- Grain bins
- Door panels.
- Poultry house pecking panel strips
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Tempered Presdwood—and other Masonite Hardboards are available through building materials dealers

"Masonite" signifies that Masonite Corporation is the source of the product

FREE SAMPLE

MASONITE CORPORATION, Dept. AE-12
Box 777, Chicago 90, Illinois.
Please send me a free sample of Masonite Tempered Presdwood and literature about Masonite Hardboards on the farm.

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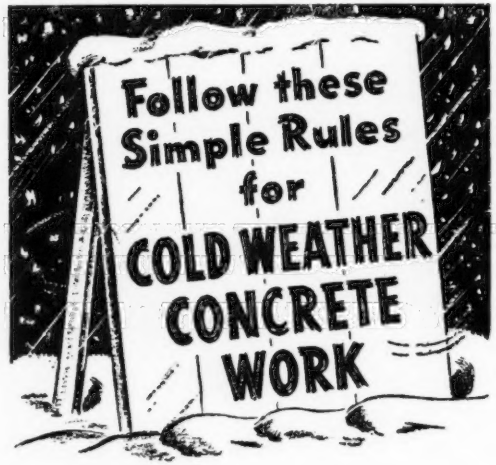


AFTER the last crops are in farmers usually have more time for construction work. Concrete improvements can be built in winter just as well as in summer, but certain precautions must be observed. These are:

1. **HEAT MATERIALS.** Concrete should be between 60° and 80° F. when placed in the forms. Heat sand and coarse aggregates separately until all frost, ice or snow disappears. The water should never be hotter than 175° F. when it comes in contact with the portland cement in the mix—otherwise a flash set may result.

   In above-freezing weather heating the water or putting a heater on the mixer may be all that's necessary to bring up the temperature of the mix.

2. **MIX CAREFULLY** so that concrete is as stiff as possible and yet will place and finish properly. Never add salts or chemicals to *prevent freezing.* Small amounts of calcium chloride (2 lb. per sack of cement) may be used to *accelerate the hardening.*

3. **CLEAN FORMS** of all frost, ice and snow.

4. **THAW GROUND** if it is frozen. Never place freshly mixed concrete on frozen ground.

5. **PROTECT CONCRETE FROM FREEZING.** Flat work can be protected with heavy paper and 10 to 12 in. of hay or straw. Walls and other structural members must be enclosed with canvas and kept warm. Do not remove forms until concrete has had time to harden properly. Normally concrete must be maintained at 50° F. or higher for five days after placing. However, with high-early-strength concrete this time period may be reduced.

PORTLAND CEMENT ASSOCIATION

Dept. 12-1, 33 W. Grand Avenue, Chicago 10, Ill.

A national organization to improve and extend the uses of portland cement and concrete...through scientific research and engineering field work

PERSONALS OF ASAE MEMBERS

C. Howard Bingham has resigned his position as extension agricultural engineer at Pennsylvania State College, effective December 31, to become associated with R. J. McCall in New Way Farm Sales, Inc. He plans to remain in Pennsylvania and operate in that part of the company's territory.

J. J. Brickley has resigned as assistant manager of the United Fruit Sugar Co., Banes, Oriente, Cuba, to accept the position of vice-president and general manager of the Standard Fruit and Steamship Co., La Ceiba, Honduras.

James L. Butler recently accepted appointment as assistant agricultural engineer with the Georgia Agricultural Experiment Station at Experiment, Ga.

Joseph Coulam, extension agricultural engineer, and *Clere H. Milligan,* in charge of irrigation and drainage, Utah State Agricultural College, are two of the 13 Utah specialists in agriculture, education, health and sanitation, and sociology, who are enroute to Iran to join the Point IV village improvement program under the auspices of the Technical Cooperation Administration (TCA) of the U.S. Department of State.

Russell E. Heston, who for the past three and one-half years has held the position of agricultural engineer with the National Association of Mutual Insurance Companies, was elected recently, during the 55th annual convention of the Association, to the office of assistant secretary. He will continue to serve as the Association's agricultural engineer in addition to his new duties in the assistant secretary's office. The Association has a membership of some 1200 mutual insurance companies, approximately 900 of which write fire and/or wind coverages exclusively on farm property.

Allan W. McCulloch, formerly an irrigation engineer in the U.S. Soil Conservation Service, and more recently associated with the Irrigation Equipment Co. and the Farm Improvement Co. of Denver in an engineering and sales capacity, was recently named president of a reorganization of the former company which is now a subsidiary of Growth Industries of Philadelphia. The main office of the company, formerly at Eugene, Ore., will be moved to Denver.

Lee M. Roche, for the past 22 years one of the western representatives of *Electricity on the Farm* magazine, was recently advanced to the position of western manager of the publication, succeeding the late Walter S. Clevenger.

Richard A. Schleusener, formerly instructor in agricultural engineering, Kansas State College, some months ago received his commission as second lieutenant from the officers candidate school at the Lackland Base of the U.S. Air Force at San Antonio, Tex., where he graduated with the highest academic standing in his class. Recently he began special study in meteorology at the Massachusetts Institute of Technology, Cambridge, under an USAF assignment.

Harry V. Snow, for the past four years tractor and implement sales manager for the Dearborn Motors Corp., was recently appointed general manager of the New Iowa Ford Tractor Co., the Dearborn Motors farm equipment distributorship at Des Moines, Iowa. This company commenced operation in November as a subsidiary of Dearborn Motors, the national marketing organization of the Ford tractor and Dearborn farm equipment.

Willie L. Ulich is on leave from his position as extension agricultural engineer, A. & M. College of Texas, and is spending a year in special study at Harvard University.

John W. Zabradnik is now employed by the Near East Foundation. His work is in the engineering phases of the Foundation's agricultural development program in Iran. Prior to taking this position he was a research fellow in agricultural engineering at Iowa State College and will graduate, in absentia, with the MSAE degree in December, 1951. He has previously been engaged in work in the foreign field having worked for a summer in Finland and Germany with the American Friends Services Committee.

NECROLOGY

WALTER S. CLEVENGER, Western manager of *Electricity on the Farm* magazine, passed away October 2 following a brief illness. He was 62 years of age. A native of Chicago, he lived in suburban Elmhurst. The position he held at the time of his passing was one he had filled for the past 22 years. He was regular in attendance at meetings of the Rural Electric Division of the ASAE, and had been a member since 1945. He is survived by three daughters, two sons, and seven grandchildren.

The Symbol of Roller Chain Quality – the Diamond

TRADE ◇ MARK

● The "Diamond" mark is more than a means of ready identification of Diamond Roller Chain. It is a symbol of unvarying quality of the product and the integrity of the maker.

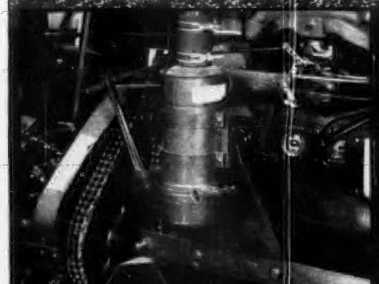
DIAMOND CHAIN COMPANY, Inc.

Dept. 616, 402 Kentucky Avenue, Indianapolis 7, Indiana

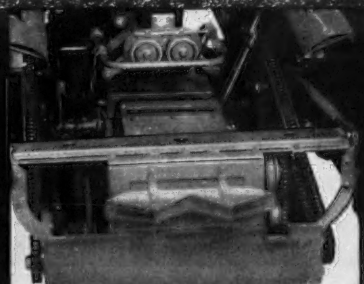
Offices and Distributors in All Principal Cities

Refer to the classified section of your local telephone directory under the heading CHAINS or CHAINS-ROLLER

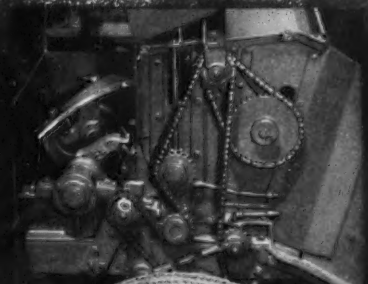
DIAMOND ROLLER CHAINS



Diamond Roller Chain drives from motor on Oliver Grain Master Combine.



Diamond Roller Chains drive gathering and husking units from power take-off on the Oliver No. 4 Picker mounted on "77" tractor.



Diamond No. 433 Roller Chain and Sprockets as used on the O. K. Harvester.

APPLICANTS FOR ASAE MEMBERSHIP

The persons listed below have applied for admission to membership, or for transfer of membership grade, in the American Society of Agricultural Engineers. Members of the Society who wish to commend or object to any of these applicants, should write the Secretary of the Society at once. If there are no objections, and if confidential statements furnished by their references are satisfactory, these applicants will be voted on by the Council after January 15, 1952.

ALLEN, KEITH J.—Parts man, Junction City Implement Co., Junction City, Ore.

ATMANTROUT, GEORGE W.—U.S. Air Force. (Mail) Scott City, Kans.

BARTHOLF, BYRON I.—Hydraulic engineer, Bureau of Reclamation, USDI, Chico, Calif.

BEAN, ELVAN L.—Agr. engr., Soil Conservation Service, USDA, Weiser, Ida.

BEIGH, NORMAN L.—Jr. engr., Lantz Mfg. Co., Inc., Valparaiso, Ind.

BENNETT, DEXTER W.—Farm serv. rep., New Jersey Power & Light Co., Flemington, N. J.

BOYCE, D. S.—Student, King's College, Durham University, Newcastle-on-Tyne, England

BUTTS, ROBERT L.—Elec. adviser, Claverack Electric Coop., Inc., Towanda, Pa.

BYRNES, ALAN W.—Irrigation engr., State Rivers & Water Supply Comm., Heyfield, Victoria, Australia

COLE, JOHN H.—Agr. tire tester, Dunlop Tire & Rubber Corp., Buffalo, N. Y.

CONWAY, RICHARD P.—Prod. education mgr., Gash-Stull Co., Chester, Pa.

COSTEDOAT, LUCIEN—Hydraulic engr., Bureau of Reclamation, USDI, Los Banos, Calif.

DOROSTI, ENAYAT B.—Student, University of Maryland, College Park, Maryland

FARLEIGH, FRANK M.—Reg. prod. spec. International Harvester Co., Oakland, Calif.

GAWRELUK, DEMETER—Trainee, Bettendorf Wks., J. I. Case Co., Bettendorf, Iowa

GREENFIELD, LYLE W.—Sales prom. supervisor, New Holland Machine Co., New Holland, Pa.

HILBE, JAMES J.—Vice-president, Hilbe Engineering, Glendora, Calif.

HUBBARD, J. L.—Mgr., Claverack Electric Coop., Inc., Towanda, Pa.

KAMMERER, REUBEN L.—Agr. engr., Soil Conservation Service, USDA, Fairfield, Iowa

LEE, JAMES A.—Mgr., Parts Dept., J. I. Case Co., Charlotte, N. C.

LOO, CHING CHEE—Graduate res. asst. in agr. eng., Michigan State College, East Lansing, Mich.

MACKSON, CHESTER J.—Graduate asst. in agr. eng. dept., Michigan State College, East Lansing, Mich.

MCBRIDE, J. E.—Agr. rep., Caterpillar Tractor Co., Peoria, Ill.

MITCALF, HERBERT J.—Student, Alabama Polytechnic Institute, Auburn, Ala.

MEYER, VERNON M.—Engr. appraiser, Federal Land Bank, Farm Credit Adm., St. Paul, Minn.

NOBLE, ROBERT W.—Sales rep., Goulds Pumps, Inc., Tulsa, Okla.

PETERSON, MERLE H.—Product engr., New Idea Div., Avco Mfg. Co., Coldwater, Ohio

QUINN, ELDRED W.—Trainee, J. I. Case Co., Atlanta, Ga.

REINHARDT, FREDERICK A.—Chief engr., Comfort Equipment Co., Kansas City, Mo.

RODDA, ERROL D.—Trainee, Caterpillar Tractor Co., Peoria, Ill.

SAHAI, MAN MOHAN—Instructor, Directorate of Education, Janta College, Alipur, Dehli State, India

SHUTE, MILTON—Graduate asst., in agr. eng., Cornell University, Ithaca, N. Y.

SMITH, TERRY E.—Agr. engr., Soil Conservation Service, USDA, Victoria, Tex.

SPIVEY, JAMES W.—Cadet engr., Louisiana Power & Light Co., New Orleans, La.

STRAUTMAN, A. J.—Agr. engr., mechanical div., Ministry of Agriculture, Khartoum, Sudan, Africa

THOMPSON, R. A., JR.—Engr., Thompson Irrigation Co., Kinston, N. C.

WARRICK, WOODLEY C.—Ext. agr. engr., North Carolina State College, Raleigh, N. C.

WHEELER, CHRIS L.—Asst. state engr., State of Oregon (State Engineer), Salem, Ore.

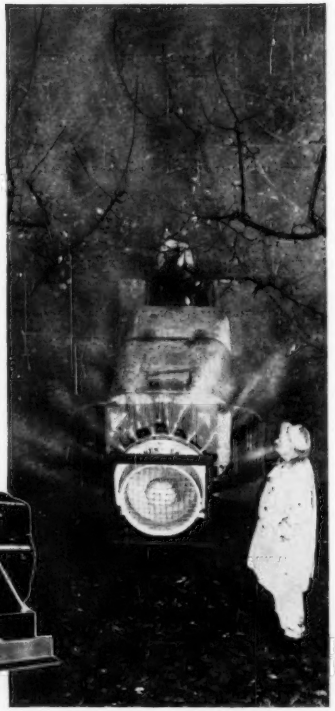
WOSTER, MALCOLM J.—Engr., Allis-Chalmers Mfg. Co., Oxnard, Calif.

Another Power Application for WISCONSIN 2-Cylinder HEAVY DUTY *Air-Cooled* ENGINES

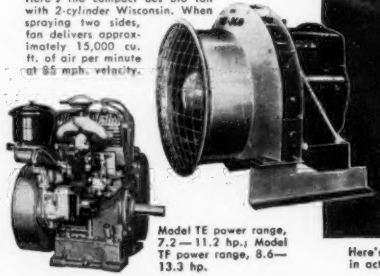
Ever since they were added to the Wisconsin Heavy-Duty Air-Cooled Engine line a number of years ago, the Models TE and TF 2-cylinder engines have met steadily growing approval among farm equipment builders and power users. The Bes Blo Sprayer, made by the Besler Corporation, Emeryville, California, is typical of this acceptance. Additionally, you'll find these rugged engines powering rotary tillers, pumps, welders and many other power-driven units.

Traditional compact, heavy-duty design, combined with light weight, foolproof AIR-COOLING, ready adaptability to installation on a great variety of equipment and quick starting in any weather are among the factors that win preference for these engines.

If you require a power unit within the 7 to 13 hp. range, it will pay you to investigate the Wisconsin Models TE and TF 2-cylinder engines. Engineering and descriptive data on request, covering all models . . . including 4-cycle single cylinder, 2-cylinder and V-type 4-cylinder types, in a full power range from 3 to 30 hp.



Here's the compact Bes Blo fan with 2-cylinder Wisconsin. When spraying two sides, fan delivers approximately 15,000 cu. ft. of air per minute at 85 mph. velocity.



Model TE power range, 7.2—11.2 hp.; Model TF power range, 8.6—13.3 hp.

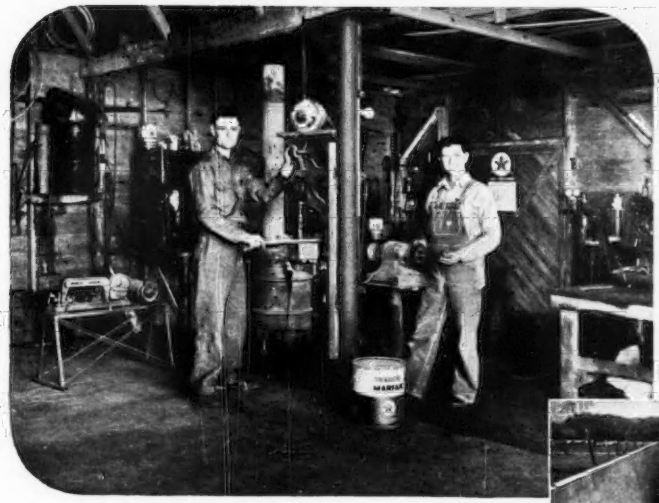
Here's the Wisconsin-powered Bes Blo Sprayer in action, spraying two rows of trees at a time.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46 WISCONSIN

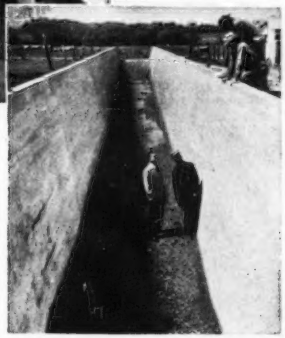
Jess Radle's Workshop saves time and money



"It's not the cost involved in taking machinery to town to get it repaired that matters so much as the loss in time," says Jess Radle (right), successful farmer near Waco, Texas. "We can do a valve job in this shop in three hours; it would take a day to get it done in town." Frank Wolf (left), farm foreman, is using a hand drill that has been converted into a power drill. Marfak lubricant is kept handy for grease jobs.

Mr. Jess Radle has in his workshop a welder, lathe, table saw, paint gun, motor cleaner, power hacksaw, electric drill, valve facing machine and a complete set of tools. "My workshop sure pays off," says Mr. Radle.

It is significant that Mr. Radle, who has such a fine repair shop and knows motors and farm machinery inside and out, has found that *it pays to farm with Texaco Products.*



400-ton silo built by Mr. Radle required 750 sacks of cement, $400 worth of steel. "It costs me only about 50 cents a ton to cut and fill the silo," says Mr. Radle (kneeling).

Mr. Radle (left) has found that it pays to use Havoline, Texaco's famous two-purpose motor oil, in his tractors, cars and trucks. Texaco Man James Monroe (right) explains that Havoline not only surpasses Premium motor oils but also exceeds Heavy Duty oil requirements, making it ideal for Diesel or gasoline engines.

It's friendly service like this along with the better quality of Texaco Products that farmers appreciate. Texaco Man Otto Nadler of Lake Mills, Wisc., has just delivered a tankful of Fire-Chief, the gasoline with superior *"Fire-Power"* for low-cost operation, to the farm of Mr. Harvey Kasten (right).

NEW TEXACO FARM MOVIE in FULL COLOR

A HEART-WARMING STORY OF "TRUDY" AND HER CALF

See prize-winning dairy cattle, and how they are judged; brilliant tulip festival in Holland, Mich., with folk dances in streets. Ask your Texaco Man when and where movie will be shown. Bring your family for an enjoyable evening.

TUNE IN...Metropolitan Opera broadcasts every Saturday afternoon. See newspaper for time and station.

IT PAYS TO FARM WITH TEXACO PRODUCTS

TEXACO REG. T.M. THE TEXAS COMPANY

DIVISION OFFICES: Atlanta 1, Ga.; Boston 17, Mass.; Buffalo 3, N. Y.; Butte, Mont.; Chicago 4, Ill.; Dallas 2, Tex.; Denver 1, Colo.; Houston 1, Tex.; Indianapolis 1, Ind.; Los Angeles 15, Calif.; Minneapolis 3, Minn.; New Orleans 6, La.; New York 17, N. Y.; Norfolk 1, Va.; Seattle 11, Wash.

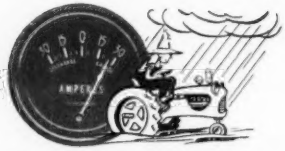
Texaco Petroleum Products are Manufactured and Distributed in Canada by McColl-Frontenac Oil Company Limited.

Rochester

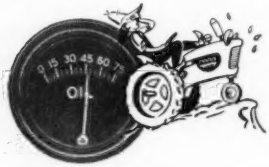
GAUGES

ARE SPECIALLY BUILT

FOR "ROUGHING IT"



ROUGH WEATHER—No danger of condensation or dirt hindering the dependably accurate performance of Rochester ammeters, temperature and pressure gauges. Fog-proof — their easy-to-read dials are hermetically sealed behind extra strong glass crystals. No plastic substitutes, no discoloration.



ROUGH GOING—Even your smoothest riding tractors have to take a lot of hard knocks—the tough, but sensitive movements of Rochester Gauges are protected with vibration and pulsation dampeners.

ROUGH USE—Always working under heavy load, temperature and pressure are high and critical. That's why tractor engines are specially built, as are Rochester Gauges to protect them.

No wonder practically all leading tractor manufacturers have been specifying Rochester Gauges as standard equipment for over 35 years.

Rochester Manufacturing Co., Inc.
99 Rockwood Street, Rochester, N. Y.

Rochester

MANUFACTURING COMPANY, INC.

DIAL THERMOMETERS GAUGES AMMETERS

Engineering Manpower Convocation

A CONVOCATION on engineering manpower, September 28, at the University of Pittsburgh, drew an attendance of some 400 industrialists, engineering educators, and secondary school representatives. The meeting was sponsored by the Engineering Manpower Commission of the Engineer's Joint Council, and the Engineering Society of Western Pennsylvania.

The American Society of Agricultural Engineers and the field of agricultural engineering were represented by W. D. Hemker, member of the ASAE Council, B. P. Hess, and J. B. Stere.

Speakers and questions from the audience indicated considerable thinking toward getting at the "grass roots" of the problem through nationwide contacts with high schools. It was pointed out that the various industries employing engineers, together with state and local organizations of engineers, are in a favorable position to establish and maintain contacts with high schools in their areas. Through those contacts high school teachers, vocational counselors, and students can be kept informed as to the need for more engineers, the opportunities for satisfying careers in engineering, and the aptitude and training requirements for success in engineering. In addition, parent-teacher associations, churches, area youth organizations, chambers of commerce, and other public service activities were suggested as potential cooperator in local drives for increased engineering college enrollments.

A. C. Monteith, vice-president, Westinghouse Electric Corp., pointed out that in order to maintain and advance our standard of living, more engineers and more scientifically trained men must be available.

S. C. Hollister, dean of engineering, Cornell University, urged industry to look after its future supply of engineers by encouraging enrollment in engineering colleges. He pointed out that the indicated need for new engineering graduates in 1951, for combined industrial and military requirements, is 95,000, and the supply about 38,000.

Dr. M. H. Trytten, National Research Council, emphasized the importance of military forces keeping track of their engineers and using them as engineers, to minimize the drain on the supply for supporting civilian activity.

Carey H. Brown, manager of engineering and manufacturing services, Kodak Park Works, Eastman Kodak Co., and chairman of the Engineering Manpower Commission, called upon the engineering profession itself to take a large part in dealing with the problem, by broadcasting information on the shortage and by other means. He also urged the individual engineer "to so devote himself to his own task that the total engineering output shall not suffer by his deficiency."

Engineering Featured in Pest Control Conferences

CORNELL University's Fourth Annual Pesticide Application Equipment Conference and the Thirteenth Annual New York State Insecticide and Fungicide Conference were held at Ithaca, New York, on November 7, 8, and 9.

The pesticide application equipment program on the first day and evening featured reports of research with low-gallonage spraying equipment for row crops and turf. O. C. French, head of the agricultural engineering department at Cornell University, presided over the forenoon and evening sessions. Dr. C. W. Terry, professor of agricultural engineering at Cornell, was chairman for the afternoon session. Attention was given to work that had been done with air-blast equipment for orchard pest control and mist concentrate spraying for both orchard and row crops as well as for grape disease control. Discussions of spreader-stickers for mist concentrate spraying and the timing and formulations used in mist blower work for elm leaf beetle control were included. An opportunity was provided to see exhibits of some of the newer application equipment.

The evening program relating to equipment consisted of a panel discussion of application equipment problems as seen from the viewpoint of a canner, a fruit grower, a vegetable grower, and a commercial pest control operator. Guest speakers from these New York state industries participated in the program.

Forty-two members of the research and extension staffs of the divisions of entomology and plant pathology at Geneva and its branch laboratories at Poughkeepsie and Fredonia, and from the departments of agricultural engineering, plant pathology and entomology at Ithaca, including the Long Island Vegetable Research Farm, participated in the three-day program.

Dr. G. L. McNew, managing director, Boyce Thompson Institute, Yonkers, N. Y., and Ernest Hart, president, Niagara Division, Food Machinery and Chemical Corp., Middleport, N. Y., were guest speakers on the opening morning of the materials conference. Dr. McNew gave an excellent presentation on some of the recent advances and the future of fungicides. Mr. Hart covered the topic of the supply outlook for the National Agricultural Chemicals Assn. and gave a stimulating analysis of his prediction for the growth of the field agricultural chemicals in the next five years.

Johns-Manville Flexboard Transitop is STRONGER...

Both surfaces are tough, fireproof asbestos Flexboard

The same properties that make J-M Asbestos Flexboard so desirable as a building sheet, make it the ideal surfacing material for Flexboard Transitop, the *structural* insulating building panel, developed by Johns-Manville. The Flexboard surface, made of asbestos and cement, is tough, strong and abuse-resistant. Fireproof and rodent-proof, it provides a smooth flush surface, which can be left as is or decorated as desired.

Impregnated core combines strength with high insulating value

Between these Flexboard surfaces is an insulating core of a special impregnated Weathertite Sheathing. This combination makes J-M Flexboard Transitop both a structural and insulating material at one time. The Weathertite core is available in thicknesses of ½" to 2" depending on the service required.

Easy to work or apply

J-M Transitop is easily handled on the job. It can be sawed, nailed *without drilling*, or drilled for bolts or other fasteners *without fear of chipping or cracking*. It offers the ease of dry wall construction and the erection advantage of large sheets in one material.

For full details about J-M Transitop, the wonderful, new structural insulating material, write Johns-Manville, Box 290, New York 16, N.Y. In Canada, write 199 Bay Street, Toronto 1, Ontario.

JOHNS-MANVILLE JM PRODUCTS

interchangeable orifice tips . . .

a feature of

SPRAYING SYSTEMS
TeeJet
SPRAY NOZZLES

Merely by changing orifice tips, users of TeeJet Spray Nozzles may change over from one type of spraying to another. Change only the tip and you've changed the nozzle! Choice of hundreds of tip sizes for any type of spraying. Only TeeJet Spray Nozzles provide all of these advantages:

- Choice of flat spray and cone spray tips for soluable chemicals . . . disc type cone spray and Cone-Jet tips for chemicals with suspended solids . . . **all** interchangeable.
- Factory testing of every nozzle before shipment.
- Comprehensive reference catalogs, to give you easy selection of the exact spray nozzle needed for any application.
- Precision orifice design . . . the design that guarantees positive, precision orifice diameters as specified, for exact spray nozzle performance.
- Built-in strainers . . . monel metal screens or milled brass cores to fit each need.
- Easy tip adjustment on all flat spray tips. Milled flat tip surfaces are parallel to plane of the flat spray.

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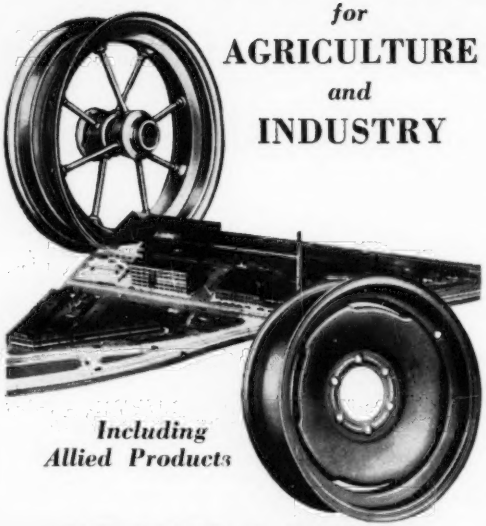

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Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated:

POSITIONS OPEN: JULY—O-301-529. AUGUST—O-320-533. SEPTEMBER—O-340-539, 353-540, 354-541, 355-542. OCTOBER—O-401-544, 396-545. NOVEMBER—O-436-546.

POSITIONS WANTED: MAY—W-253-54, 276-56. JUNE—W-232-60. AUGUST—W-310-69, 315-70, 292-71. SEPTEMBER—W-331-72, 333-73, 334-74. OCTOBER—W-383-76, 391-78, 398-79. NOVEMBER—W-419-80.

NEW POSITIONS OPEN

CHIEF ENGINEER for design department in the organization of a well established spray equipment manufacturer in the Midwest. Expansion program includes opportunity for work in an undeveloped field. BS deg in agricultural or mechanical engineering. Agricultural equipment design and production method experience essential. Supervisory experience desirable. Ability and good personal appearance required. Progressive management. Opportunity up to individual. Age 30-45. Salary $7000-8000. O-457-547

SALES REPRESENTATIVE and OFFICE ENGINEER openings in district office of an established manufacturer of farm water systems. Location Oklahoma and neighboring states. College education or high school plus experience in farm trade. Want young men mechanically inclined, with good personality and appearance, and willing to work for advancement. Company has own training program. Sales work is contacting distributors. Office engineer will handle calls, quotations, and correspondence on irrigation, drainage, municipal and industrial pumps as well as farm water systems. Excellent opportunity for advancement. Age 25-30. Salary $3300 start. O-451-548

DESIGN ENGINEER for design and development of sprayers, dusters, and various insecticide applicators, with eastern plant of a large manufacturer. Work on specific project or variety of projects, depending on individual. BS deg in agricultural or mechanical engineering. Farm background and experience with power machinery preferred. Must be good cooperator and team worker. Excellent opportunity for advancement in small engineering department in a growing concern, or in larger or newer division of the business. Salary open. Insurance and annuity plans available. O-450-549

EXTENSION AGRICULTURAL ENGINEER for work primarily in soil conservation, with limited work in general agricultural engineering, in an eastern state. About 100 days travel per year. BS or MS deg in agricultural engineering. Farm background. Usual personal traits for public service positions. Opportunity for advancement good. Age 25-35. Salary open. O-473-550

FARM MACHINERY DESIGNERS (all grades), trainees, draftsmen and field test men needed for positions in expanding Engineering Division of a leading farm machinery concern in the East. These are openings which cannot be filled by promotion of present staff and offer opportunities for professional advancement to men of good character who wish to join a really progressive group. Ideal engineering facilities, including air-conditioned offices, located at edge of small city. Salaries commensurate with background, experience, and ability. O-480-551

NEW POSITIONS WANTED

DESIGN, development, or research in farm structures or soil and water field in industry or public service, preferably in northern U.S. or in Canada. Willing to travel. BS deg in agricultural engineering 1949, University of Maine. Farm background and some sales experience. Present temporary work, substitute clerk carrier, U.S. Postal Service. Married. Age 24. No disability. Available on reasonable notice. Salary open. W-459-81

DESIGN, development, or research in power and machinery or soil and water field, in industry or public service anywhere in U.S.A. BS deg in agriculture expected June 1952, Cornell University. Farm background. Automobile service with dealer, 2 yr. Part time work in school as teaching assistant in welding, electrician's helper, and carpenter's helper. Single. Age 21. No disability. Available July 1, 1952. Salary open. W-464-82

DESIGN, development, research, or sales in sprinkler irrigation or related field, in industry or public service, anywhere in U.S.A. BS deg in agricultural engineering, 1950, University of Minnesota. Farm background. War service in Navy over one year. Present work sales engineer including sprinkler irrigation layout, design, sales correspondence, and some design work on irrigation equipment. Married. Age 25. Slight disability. Available on reasonable notice. Salary open. W-461-83

DEVELOPMENT or research in the soil and water field with industry or public service in U.S.A. or in Central or South America. BS in agriculture, 1949, University of Missouri. Major in soil conservation, minor in field crops. Only one full semester required toward agricultural engineering degree. Native of Lima, Peru. Permanent resident visa and 5 yr residence in U.S. Self-employed importer-exporter. Knowledge of rural sociology, psychology, geography, crops, rotation systems, agricultural engineering problems, etc. in various South and Central American countries. Some experience with terracing, contouring, irrigation, etc. on farms in South America. Married. Age 27. No disability. Available on 4 weeks notice. Salary $3600. W-454-84 *(Continued on page 700)*

Nothing can stop you now!

Not ice-slick ground or churning mud. Not steep inclines or shifty sand. Where you want to go, you *go,* on your Oliver "OC-3." You're riding the king of the hills . . . the bull of the bottom lands . . . *nothing* can stop you now!

Think what this means when rain threatens your harvest, when soft spots hold up your plowing—it just can't *happen* to the owner of an "OC-3"!

Even as your Oliver walks through the toughest going, it walks with an easy tread. Its weight-distributing tracks will never pack your soil . . . never dig ruts to trip your planter.

A wide choice of treads—31, 42, 60, and 68-inch—suits the "OC-3" to every crop requirement, including row crops. Nor does its usefulness end in the field! The "OC-3" is an *all-around hand,* ready with belt pulley and power take-off to help with any chore, any season.

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Over 65 years in wheel manufacturing have given us the "know how"—modern production methods assure long life and efficient wheel performance in the field.

There is an ELECTRIC spoke or disc wheel for most types of portable equipment. Axles are available where required.

Our experienced engineers are ready to assist you in solving your wheel and axle problems and we will offer our recommendations upon receipt of your specifications.

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Through 15 years, under all kinds of conditions throughout the world, Rain Bird Sprinklers have proved their dependability in faultless, low-cost performance.

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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

Personnel Service Bulletin

(Continued from page 698)

EXTENSION, research, sales, service, or writing in power and machinery or soil and water field, in industry or public service, preferably in South Central area. BS deg in agricultural engineering 1951, Oklahoma A. & M. College. Farm background. Certified welder in aircraft factory 4 yr. War service in Field Artillery 2½ yr. Part time work as maintenance welder while in college. Presently employed as engineering draftsman on layout and detailing of hydraulic equipment with manufacturer. Married. Age 28. Slight disability in arms. Available January 1. Salary $3825. W-467-85

DESIGN, development, research or writing in soil and water or farm structures field, in industry anywhere in U.S.A. Willing to travel part time. BS deg in agricultural engineering November 1951, Michigan State College. Farm background. Worked for one employer during summer months of high school and college years. War service in Army 1½ yr. Married. Age 24. No disability. Available January 1. Salary $3600. W-474-86

RESEARCH development, or design in farm structures or power and machinery field in industry or public service, anywhere in U.S.A., possibly elsewhere. BS deg in agricultural engineering expected February 1952, University of Massachusetts. Training includes theory of structures and advanced structural design. Four summers building concrete stave silos for a New England distributor. War enlisted service 1½ yr in Pacific and Japan (Gen. MacArthur's Headquarters). Single. Age 23. No disability. Available February or March. Salary open. W-471-87

DESIGN, development, or research in soil and water field, in industry or public service in U.S.A. or elsewhere. BS deg in agricultural engineering expected January 1952, Oklahoma A. & M. College. Experience 3 mo in topographic surveying, U.S. Soil Conservation Service. Single. Age 22. No disability. Available February 1. Salary open. W-470-88

DESIGN, development, research or writing, in power and machinery field, with industry or public service, preferably in Canada. BE degree in agricultural engineering, 1950, University of Saskatchewan. MS degree in agricultural engineering, with minor in mechanical engineering expected winter 1952, University of Minnesota. Two summers in extension work. Half-time teaching assistant 3 quarters. Half-time research assistant 2 quarters. Married. Age 24. No disability. Available about March 1952. Salary open. W-477-89

NEW BOOKS

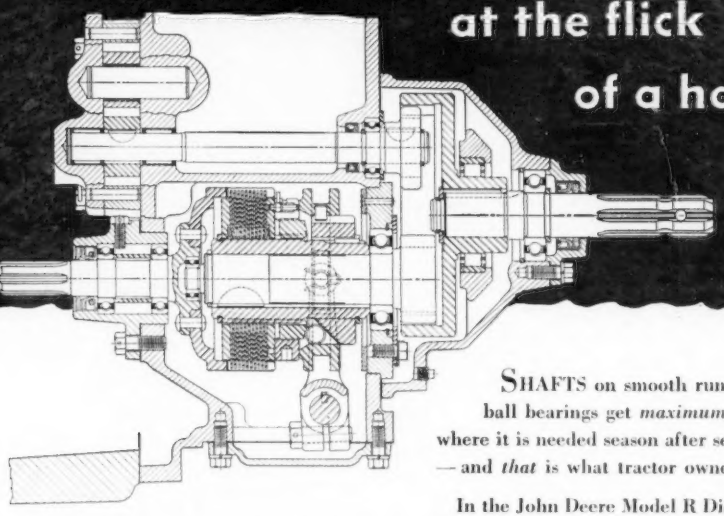
IRRIGATION ENGINEERING (vol. 1), Agricultural and Hydrological Phases, by Ivan E. Houk. Cloth, X+545 pages, 6 x 9 inches. Illustrated and indexed. John Wiley and Sons, Inc. (440 Fourth Ave., New York 16, N. Y.) Regular edition $9.00, college edition $7.50.

A text and reference planned to bring together up-to-date information on the indicated phases of the subject. Project planning and structures are purposely omitted as a second major division of the subject appropriate to a separate volume. Sixteen chapters cover introduction, irrigation soils, soil fertility, moisture in irrigation soils, soil-moisture movements, climatic factors, runoff and streamflow, snow melting and runoff forecasting, evaporation from water surfaces, land evaporation and transpiration, irrigation and water requirements, losses and waste of irrigation water, irrigation water supplies, quality of irrigation water, irrigation of saline and alkali soils, and irrigation preparations and procedures.

FUNDAMENTALS OF SOIL SCIENCE, by C. E. Miller and L. M. Turk. Second edition. Cloth, X + 510 pages, 6 x 9 inches. Illustrated and indexed. John Wiley and Sons, Inc. (440 Fourth Ave., New York 16, N. Y.) $5.00 (Canada, 25 per cent higher).

A college text for the introductory or general course in soils, extensively revised and brought up to date with new knowledge in soils and related fields. Chapters cover materials for soil development, processes of soil development, physical properties of soils, classification of soils, chemical properties of soils, soil reaction, lime and its use, soil moisture, soil organisms — kinds, numbers, activities, and relation to soil productivity, soil organic matter, cover and green-manure crops, farm manures, nutrient requirement of plants, fertilizers and fertilizer materials, fertilizer practices, conserving soil, soil fertility maintenance and productivity rating of soil, soils and agriculture and arid regions, irrigation and soil resources.

Back Saving Power at the flick of a hand



Direct engine-driven Power Take-off and Hydraulic "Powr-Trol" pump for operation of attachments to the John Deere Model R Diesel Tractor are engaged or disengaged at will by an independent clutch.

SHAFTS on smooth running New Departure ball bearings get *maximum* power right thru to where it is needed season after season without change — and *that* is what tractor owners really appreciate.

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138

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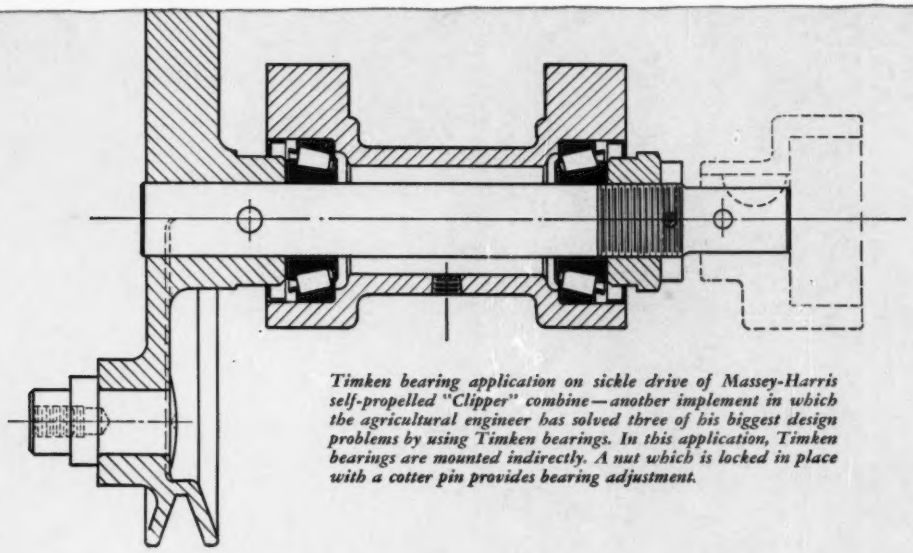

Timken bearing application on sickle drive of Massey-Harris self-propelled "Clipper" combine—another implement in which the agricultural engineer has solved three of his biggest design problems by using Timken bearings. In this application, Timken bearings are mounted indirectly. A nut which is locked in place with a cotter pin provides bearing adjustment.

How Massey-Harris mounts sickle drive to lick shock-load problem

IN the Massey-Harris self-propelled "Clipper" combine, the sickle bar is moved back and forth by a 6″ throw arm. Engineers at Massey-Harris knew that the high speed of the crank, plus the heavy weight of the crank arm, would result in high shock-impact loading on the crank bearings. So they specified Timken® tapered roller bearings at that vital point.

Timken bearings take heavy shock loads for these reasons: Line contact between Timken bearing rollers and races gives extra load capacity; case-carburizing of Timken bearing rollers and races gives them a tough, shock-resistant core with a hard, wear-resistant surface; and Timken bearings are made of the finest material ever developed for tapered roller bearings—Timken fine alloy steel.

In addition to insuring friction-free operation under the heaviest shock loads, Timken bearings also make closures more effective by keeping housings and shafts concentric. And due to tapered construction, radial and thrust loads are carried with ease.

Timken bearings help implement engineers solve three of their biggest design problems at once (1) dirt, (2) combination loads, (3) ease of operation. And Timken bearings assure implement users of longer implement life, less chance of breakdowns on the job.

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